ANITARY WORKS ABROAD.

I.

" ASSAINISSEMENT DE LA SEINE."

ORT OF THE COMMISSION APPOINTED TO PROPOSE MEASURES FOR
REMEDYING THE POLLUTION OF THE SEINE IN THE
VICINITY OF PARIS.

II.

"ASSAINISSEMENT DE BERLIN."

DESCRIPTION OF THE WORKS IN COURSE OF EXECUTION FOR THE
SEWERAGE OF BERLIN, AND THE APPLICATION OF THE SEWAGE
TO IRRIGATION AT MARIENFELDER AND FALKENBERG.

tracted from the 'Annales des Ponts et Chaussées,' and Translated
from the French

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TRANSLATOR'S NOTE.

THE question of the pollution of rivers by the sewage of large towns is one which has forced itself on public attention, and is now of universal interest. A particular case, that of the Seine, is ably discussed in this Report. The present translation is as literal as the idioms of the two languages, and the difficulty of selecting words having precisely the same meaning in both, would admit of. The French weights and measures have not been turned into their English equivalents, the following table will supply the means of doing so if required :—

WEIGHT.—*Gramme* = 15·44 English grains.
Kilogramme = 1000 grammes = 2·2057 avoirdupois lbs. 1000 kilogrammes = 1 ton English nearly.
CAPACITY.—*Litre* = 1·7608 pints. 100 litres = 22 gallons nearly.
Cubic Centimètre = 1000th part of litre = 0·0613 cubic inch.
LENGTH.—*Mètre* = 100 centimètres = 39·3708 inches = 3·2809 feet.
Kilomètre = 1000 mètres = 0·62138 mile. 100 kilos. = 62 miles nearly.
SURFACE.—*Hectare* = 100 ares = 2·4736 acres. 2 hects. = 5 acres nearly.
Centiare = 1 square mètre = 1·1960 square yard.
MONEY.—*Franc*, value variable, say 25 francs = 1*l.* sterling.

R. M.

DUBLIN, *May* 19, 1876.

While the translation of the Report on the Seine was passing through the press, the May number of the *Annales* came to hand. It contains a notice by M. Mille of the sewerage and irrigation works, now in course of construction, at Berlin, and alluded to by him in the last paragraph of his note on the Seine Report.

At Berlin the proper drainage, water supply, and ventilation of private houses are made compulsory, and neglect on the part of the owners is punished by fine or imprisonment. In this country such neglect executes its own "*arrêt*," and, more frequently than is supposed, punishes with death.

M. Mille says that the water-closet is especially the *point d'appui* of domestic salubrity. Badly constructed, badly trapped, unventilated, it becomes a domestic Upas.

There are indeed three requisites to the domestic salubrity of the dwelling—WATER, DRAINAGE, VENTILATION. If these be properly supplied, many of the evils (some of them unsuspected) which the want of those requisites create, and under which we suffer, will disappear, health will return, and to such a system may be applied the Menavian motto:

"QUOCUMQUE JECERIS STABIT."

R. M.

DUBLIN, *June* 20, 1876.

PURIFICATION OF THE SEINE.

Report of the Commission appointed to propose Measures for remedying the Pollution of the Seine in the vicinity of Paris.

INTRODUCTION.

Nomination of the Commission.—By a decree dated the 22nd August, 1874, the Minister of Public Works appointed a Special Commission to propose measures for remedying the pollution of the Seine in the vicinity of Paris.

Its Composition.—On this Commission were represented the department of Public Works, the services presided over by the Prefect of the Seine and the Prefect of Police. *

The Commission now presents the following Report.

Historical Summary.—The department of Public Works has been more than once engaged in the consideration of the pollution of the waters of the Seine near Paris. By virtue of a ministerial decision of the 23rd October, 1869, conferences took place between the engineers of the navigation and of the municipal authorities of the City of Paris.

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* The Commission was composed as follows:—

Department of Public Works.—M. Kleitz, Insp.-Gen. *des Ponts et Chaussées*, President; M. Chatony, I. G. P. et C.; M. Krantz, Engineer-in-Chief Third Section of the Seine.

Department of the Prefect of the Seine.—M. Belgrand, I. G. P. et C., Director of the Water Supply and Sewers of Paris; M. Alphand, I. G. P. et C., Director of Works, Paris; M. Mille, I. G. P. et C.; M. Vaudroy, Engineer-in-Chief Second Section of the Seine; M. Callon, Town Councillor, Paris; Dr. Depaul, Town Councillor, Paris.

Department of Commissioners of Police.—M. Chevallier, Member of the Council of Health; M. Boudet, Member of the Council of Health; M. Alfred Durand-Claye, Engineer P. et C., Secretary.

In the year 1870 the latter made a general preliminary Report on the utilization and purification of the sewage waters. The conclusions arrived at by the engineers in consultation formed the subject of two Reports made by M. Kleitz, dated the 2nd March and 15th July, 1870, which were discussed by the Council General *des Ponts et Chaussées*. In a despatch of the 31st July of the same year the Minister of Public Works transmitted (with his approval) the opinion of the Council General to the Prefect of the Seine. From this opinion it resulted:—

1°. That the City of Paris was bound to remedy the evils arising from the discharge into the Seine of the intercepting sewers of Clichy and St. Denis.

2°. That with this object the City of Paris should on the one hand maintain a satisfactory dredging establishment, and on the other continue and develope the experiments undertaken at Gennevilliers for the purification of the sewage by applying it to irrigation, and purification by means of sulphate of alumina. The attention of the Prefect of the Seine was called to the preliminary scheme drawn up by the municipal engineers in the year 1870, as suitable to the attainment of this last object.

Some days after the above-mentioned ministerial decision the events of the war caused profound trouble in the outskirts of Paris. After the struggle with the Prussians and the Communists the municipal administration of the City of Paris was reorganized on a new basis, the attempts at the utilization and purification of the sewage waters were resumed, and considerably extended. On the other hand the inconvenience resulting from the discharge of the sewage into the Seine was daily getting worse and worse.

The Commission have had therefore before them facts more numerous and more plainly characterized than in the year 1870. They sought during many meetings and examination of the ground to fulfil in the best manner possible the task imposed upon them, and to respond to the intention of the Minister of Public Works by viewing the question in all its aspects as recommended in his letter of the 21st July, 1874, to the Prefect of the Seine.

Divisions of the Report.—The work of the Commission naturally divides itself into two distinct parts :—

1°. Examination of the pollution of the Seine in the vicinity of Paris, and an investigation into the causes of it.

2°. Examination and selection of the measures to be taken to remedy this pollution.

These are the two great divisions of this Report.

FIRST PART.

EXAMINATION OF THE POLLUTION OF THE SEINE IN THE VICINITY OF PARIS. CAUSES OF THIS POLLUTION.

Phenomena which characterize the Pollution of the Seine.—The phenomena which characterize the pollution of the Seine are of two kinds. Some apparent, of a physical or physiological kind, and easily catching the attention of anyone who walks along the banks of the river. Others more scientific, which require the aid of chemistry fully to appreciate them; they define in a very precise manner the facts of the pollution and give the means of following their development and propagation.

Outward Characteristics of the Pollution of the Seine.—To make themselves acquainted with the apparent character of the pollution of the Seine, the Commission inspected on the 11th of October the part of the river most seriously affected, viz. that between Clichy and Rueil. Some of its members have made this inspection complete by communicating observations which they made on parts of the river above and below the above-named section. From the various observations thus made result the following facts :—

Above Paris, as well as between the fortifications and Asnières, the Seine presents a satisfactory appearance, at least to a superficial observer. The progress made in the great work of the sewerage of Paris and the intercepting sewers manifests itself in a very evident manner. At certain points, on both sides of the river, streams of impure water flow from different manufactories or from the suburban sewers, and even from those of Paris not yet connected with the intercepting sewers; but those are rapidly lost in the mass of the river. Fishes live in its entire width; vegetation of a high order shoots upon the banks; the bottom of the Seine is composed of white sand. During the heat and drought of last season the relatively satisfactory state of this reach of the Seine for its whole length has been universally experienced.

Below the bridge of Asnières there is a sudden change. Upon the right bank is the great intercepting sewer of Clichy. A considerable current of blackish water flows from this sewer and spreads itself across the Seine, forming a parabolic curve. This curve occupies a variable length—at ordinary times it reaches half across the river; during heavy rains it approaches the left bank. This water is very filthy: it carries with it organic *débris* of all sorts, vegetables, wisps of straw, flocculent matter, hair, the dead bodies of domestic animals, &c. It is usually covered with a layer of greasy matter, which accumulates on one bank or the other, according to the direction of the wind; gray mud mixed with organic *débris* accumulates along the right bank, and forms shoals which, at certain times of the year, rise to a considerable height above the surface of the water, and are only got rid of by means of costly dredgings; this mud descends to the lowest part of the bed (*thalweg*). It is the seat of an active fermentation, which transfers itself by innumerable bubbles of gas, which burst at the surface of the water. During a great part of the year, and especially in times of great heat, these bubbles attain to considerable dimensions (1 mètre to 1·5 mètre in diameter); they drag the mud with them, and bring to the surface black and filthy matter, which flows with the stream and on its surface; the passage of a boat raises waves of foam and creates a complete ebullition, which lasts some minutes in the wake of the boat. All these phenomena were produced in 1870 on the right bank only, and the pollution was not apparent except on the first of the three branches which the Seine forms at Clichy, between the islands Vaillard and Robinson. The second branch is now in the same state, and there is a visible pollution on the right bank of the third one. No living thing, no fish, no green grass, is found on the right branch; on the middle branch fish sometimes appear, and are again found in the left one. During floods when the sewage water spreads across the entire width of the Seine, fish are sometimes destroyed (even at the places where they habitually resort) by the general and temporary pollution of the river. On the central branch there is a moderate vegetation. There is a vigorous growth on the left branch. From the isles of Clichy down to the island of St. Denis the pollution continues, although a little less visible at the surface; the water has a blackish colour, the right bank is always fringed with foam and scum; the pollution seems to stretch quite across the river; and the left beach is garnished with vegetable refuse, wisps of straw, &c., and with a thin coat of slimy mud.

At St. Ouen commences the isle of St. Denis, which extends to within two kilomètres of Argenteuil and divides the river into two distinct branches. The left branch, supplied by the part of the river less contaminated with sewage and not receiving any fresh affluent of polluted water, is moderately pure. The right branch, fed by the current from the intercepting sewer of Clichy, which flows along the right bank of the river, has, opposite St. Ouen and below it, the same polluted appearance as at Clichy, which gradually diminishes down to the suspension bridge of St. Denis. The mud also, which at the request of the Commission was spread over the bottom of the river by the engineers of the navigation, and which at Clichy attains to a depth of from two to three mètres, is only sixty-five centimètres at St. Ouen.

At St. Denis a large influx of water used for manufacturing purposes increases the pollution, but its effect is little when compared with that of the intercepting sewer which empties itself a few mètres below the suspension bridge. This sewer discharges water absolutely black and fetid with a very strong ammoniacal smell; this water occupies the whole width of this branch of the river. The whole surface is covered with froth, bubbles of gas disengage themselves on all sides; this state of things is nearly constant down to the village of Epinay. The bottom of the river is covered with a black viscid fetid mud, swarming with reddish worms which are only found in the most contaminated drainage from cesspits. This mud periodically appears above water at the mouth of the intercepting sewers, and must be removed by dredging.

Let us here remark that the river Croult, which enters the Seine between St. Denis and Epinay, contributes a very considerable quantity of factory water to the polluted flow from the intercepting sewer. From Epinay to Argenteuil an apparent amelioration manifests itself, especially when the two branches reunite at the extremity of the Isle St. Denis; the water, still of a deep colour, has rarely any *débris* floating on the surface, mud has gradually disappeared, and fish make their appearance in the ordinary state of the river. From Argenteuil to the weir (*barrage*) at Bezons the Seine presents a very fair appearance, but at the level of the weir in the left branch, formed by the Isle Chiard and its appendages, there is again a very strong smell, the impure waters seem to be thrown back by the weir on the left bank, and black mud about seventy centimètres thick reappears over the entire width of the branch. The smell, however, soon disappears, a most abundant vegetation clothes the two banks, and even partly impedes the course of the river by large sheets of water plants. At Marly the wing walls of the lock are covered with a black and fetid deposit, froth extends along the whole length of the weir and its fittings. The water has always a deep tint, which is observable also in the branch opposite Chatou. Below Marly the two branches again reunite, the dark colour of the stream gradually diminishes, the water is still muddy and has a disagreeable taste as far as St. Germain and Maison Lafitte; below this towards La Frette and Conflans, and especially after the confluence of the Oise, the Seine has again an appearance sensibly the same as it had above the intercepting sewers. At Meulan all visible sign of pollution has disappeared.

CHEMICAL CHARACTERISTICS OF THE POLLUTION OF THE SEINE.

Nitrogen and Oxygen.—This simple description of the actual state of the Seine in the vicinity of Paris is without doubt sufficient to indicate the serious nature of the case, but the Commission have thought it well to add to the facts ascertained by observation some borrowed from more scientific researches. They have therefore made use of information derived from authorized sources, among which should be mentioned the analyses made at the *École des Ponts et Chaussées*, and the researches upon dilated gases* made by M. Boudet, member of the Board of Health, and M. Gérardin, officer of health of the *arrondissement* of St. Denis, after the method of M. Schutzenberger, director of the laboratory of the Sorbonne.

From a chemical point of view the impure waters which flow into the Seine produce two distinct effects—the mineral matter which they contain either in suspension or in solution encumbers the bed of the river, and affects its normal condition by simple mixture; the mechanical removal of deposits and the dilution by the current alone of the substances in solution, strictly speaking, will cause this pollution to disappear. But when the affluent waters contain organic matter, either animal or vegetable, when at the same time the velocity of circulation is inconsiderable, as in the Seine, the river itself becomes the seat of numerous decompositions which contaminate its waters in a remarkable degree, and give them for long distances a special character of pollution which cannot be neglected in regard to the public health. Organic matters change indeed in the river itself into carbonic acid, water, carburates of hydrogen, ammonia, hydrosulphuric acid, and different mineral substances. This change always implies an absorption of oxygen borrowed from gases dissolved in the water, and a production of mineral azotic bodies. As long as the last are abundant the water is absolutely unwholesome, susceptible of fermentation, unfit for any use whatever, even for the watering of the public streets. When fermentation is accomplished, when the organic matter has passed into the state of mineral matters inoffensive in themselves, the water at the same time presents a diminution in dissolved oxygen, and a disappearance of azotic organic matter, replaced by azotic mineral matter—by ammonia. The water then becomes suitable for most uses; for a while it is poor in oxygen, but the absence of it is a consequence, and not of a similar character to fermentation. A simple mechanical action, such as the fall over a weir, will restore it to its original state, and render it at last really fit for drinking.

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* In the month of June, 1874, the Board of Health, in consequence of strong remonstrances made by the Prefect of the Seine on the part of the inhabitants on the banks of the river, respecting the pollution of its waters by the intercepting sewers of Paris, requested M. Boudet to report thereon at their meeting on the 23rd of October. After having considered this Report, they requested the Prefect of Police to urge upon the municipal authorities the necessity of proceeding at once to ascertain the facts necessary to solve the important problem of the purification of the Seine. This Report, which was referred to the Commission, gives in detail the quantities of oxygen in solution in the waters of the Seine, at a great many points above Paris, as far as Corbeil, within the City itself, and below it down to Rouen.

The particulars of the quantities of oxygen stated in the present Report are taken from the oxymetric analyses of MM. Boudet and Gérardin.

To measure the state of pollution of the river, the Commission have sought for the quantity of azotic mineral matter not yet changed into ammonia which the water contains at different points. This quantity indicates the true pollution of the river by showing the exact quantity of matter still capable of entering into fermentation. The quantities of oxygen form the complement of these first researches, they fix the intensity of the fermentation already produced, they measure the final result of the reaction accomplished. The two are complete in themselves, and explain each other.

The following table gives the particulars:—

Places where the Samples of Water were taken.	Nitrogen not yet transformed into Volatile Ammoniacal Salts or Organic Nitrogen. Expressed in grammes, per cubic mètre (1000 litres). Analysis 1874.	Total Nitrogen, including Volatile Ammoniacal Salts—grammes per cubic mètre. Analyses 1869 and 1874.	Dissolved Oxygen, expressed in cubic centimètres per litre of Water.
	grammes.	grammes.	cubic centimètres.
Bridge of Asnières, above intercepting sewer	0·85	1·5	5·34
At the mouth of Clichy intercepting sewer	0·85	29·5	5·34
Clichy, below the intercepting sewer Right branch	1·51	4·0	4·60
Central branch	1·28	4·0	
Left branch	1·25	4·0	
St. Ouen, right branch	1·16	2·0	4·07
St. Denis, right branch, above intercepting sewer	1·16	2·0	2·65
At the mouth of the departmental sewer	1·16	98·0	2·65
St. Denis, right branch, below intercepting sewer and the Croult	7·27	7·0	1·02
Epinay, right branch	1·26	3·0	1·05
Bezons, for whole width of river	0·87	0·9	1·54
Marly, left branch, above the weir	0·78	3·5	1·91
Marly, below the weir	0·81	3·5	1·91
St. Germain	0·76	2·2	1·91
Maisons Lafitte	0·79	2·5	3·74
Conflans	0·46	2·5	3·74
Poissy	0·45	2·2	6·12
Triel	0·50	2·2	7·07
Meulan	0·40	2·2	8·17
Nantes	0·40	1·4	8·96
Vernon	0·40	1·4	10·40
Rouen	0·40	1·4	10·42

Observations.—In the left branch formed by the Isle St. Denis there are the following quantities of nitrogen opposite Epinay:—

	Cubic centimètres.
Organic nitrogen	0·35
Total nitrogen	1·50
Oxygen	5·00

From this table it will be seen that the quantity of organic nitrogen, which reaches 0·85 gramme per cubic mètre above the intercepting sewer at Clichy, is more than 1·5 gramme in the right half of the stream after it receives the contents of this sewer. The total nitrogen exceeds 1·5 gramme at the bridge of Asnières, below Clichy it is 4 grammes, lower down it is 2 grammes, and below the departmental sewer it is 7 grammes. On the left half of the stream the pollution is sensible at Clichy, where the quantity of organic nitrogen is 1·25; below St. Ouen there is a manifest improvement on this side of the river, and opposite St. Denis the quantity in this branch is only 0·35 gramme.

Returning to the right branch, we find at Epinay 1·26 gramme of organic nitrogen, and 3 grammes altogether. At Bezons the quantity of organic nitrogen for the whole width of the river is the same as it was at Asnières; it remains the same down to Marly. The total quantity of nitrogen, which is small at Bezons, reaches 3·5 grammes at Marly. This total quantity, which is very poor in organic nitrogen, indicates that the change from organic to mineral matter has been almost accomplished. Below Marly and down to Meulan organic nitrogen is continually diminishing. At Meulan it is but half what it was, even above the intercepting sewer. At this point, then, the water is chemically very pure; the organic causes of fermentation have almost entirely disappeared. As to the oxygen which follows fermentation, at the bridge of Asnières it is 5·34 cubic centimètres; it varies between 4·6 at Clichy (a mean of the three branches) and 2·6 at St. Denis (right branch); below St. Denis it is at its minimum, where it is scarcely 1 cubic centimètre. The quantity down to Marly is very small, only 1·91; it then gradually increases, and between Maison Lafitte and Conflans it is again the same as at the bridge of Asnières, and finally reaches 8 to 9 centimètres from Meulan to Mantes. As to the left branch formed by the Isle St. Denis, between St. Ouen and Argenteuil, the oxygen as well as the nitrogen shows a sensible improvement opposite St. Denis, where the oxygen is 5 centimètres.

It follows then from these figures that the water is greatly polluted by fermentable organic matter for the whole width of the river from Clichy to St. Ouen, all along the Isle St. Denis on the whole of the right branch, and is in this particular the same as at Asnières, between Bezons and Marly; and in this last reach it is still charged with mineral azotic matter; that besides this the water, robbed of its oxygen down to the end of the Isle St. Denis, is insufficiently aërated down to Marly and below it, only regains the same state as at Asnières below Maison Lafitte, and is not of good quality till it reaches Meulan. At this point the water is altogether renewed by the transformation of organic nitrogen into mineral matter, and by the restoration of the oxygen which it had lost in fermentation.

Scientific considerations thus confirm the facts which result from simple superficial observation. In a word, between Clichy and the extremity of the Isle St. Denis above Argenteuil, the water of the Seine, in the branch into which the intercepting sewers discharge, is absolutely unfit for any domestic purpose. It contains fermentable elements ready to be decomposed and to spread pollution; dissolved oxygen has almost entirely disappeared.

Between Argenteuil and Marly, upon the left branch, the water becomes less impure, and from a chemical point of view it is available for most uses to which it is put by the riparian inhabitants; while it is not unfit for use, it still has an insufficient aëration, and contains a considerable proportion of mineral nitrogenous substances. Below Marly the improvement is progressive; the water at Conflans is reasonably good, and at Meulan it is of good quality.

The Commission cannot close the scientific description of the pollution of the Seine below the intercepting sewers without alluding in passing to the gas resulting from fermentation, which they observed escaping in large quantities from Clichy to the extremity of the Isle St. Denis, precisely in that reach of the river where the successive absorption of oxygen occurs. The municipal engineers have furnished an analysis of these gases, made at their laboratory at Clichy in the year 1871.

	Per cent.
Carbonic acid gas	72·88
Carbonic acid	12·30
Carbonic oxide	2·54
Hydrosulphuric acid	6·70
Sundries	4·58
	100·

It will be observed that the gas is principally composed of the carbonic acid gas (*gaz de marais*)—it burns with a bluish flame. Besides the suffocating elements (carbonated hydrogen and carbonic acid) it contains poisonous elements (carbonic oxyde and hydro-sulphuric acid), and in fact, a small animal placed under a receiver filled with gas dies instantly. The knowledge of the existence of this gas caused one of the members of the Commission to entertain fears as to the immediate danger to the public health from its permanent emission; but after discussion the majority of the Commission did not concur in these fears. It was pointed out that the gases evolved were immediately diluted by a considerable mass of air, that there was no fact showing that any danger whatever was imminent; that persons employed in the sewers and in the removal of night-soil were not subject to any serious ailment specially due to the impure air which they breathed every day; and, finally, if the complaints of the residents on the banks of the Seine were incessant, and becoming more energetic every day as to the quality of the water in the river, there were no complaints whatever as to the pollution of the atmosphere; and that, on the contrary, the banks of the Seine at Argenteuil, Bezons, Chatou, and Bougival, covered with villas, had the reputation of pure air, which they could not preserve if they were affected by these special causes. The Commission therefore conclude that in the actual state of things there is no reason to believe that the gases proceeding from the Seine have any immediate or direct effect on the public health.

Finally, that the complete solution of the problem of the purification of the river is the removal from the Seine itself of the contaminated water, and that thus will disappear the elements of fermentation, and consequently the mephitic gases which they produce.

CAUSES OF THE POLLUTION OF THE SEINE.

1°. *Predominant Causes, Waters from the Intercepting Sewers, their Daily Quantity, their Composition.*—The description of the state of the river just given clearly shows what are the predominant causes of its pollution: these causes are evidently the efflux of the sewage waters of Paris. Without entering, therefore, into the details of the special reports made by the municipal engineers on the sewage water, the Commission will terminate the first part of this Report by giving some figures, which will give an idea of the quality of this water taken by itself before its mixture with the waters of the river. These figures will be the proof (in some degree mathematical) of the strong influence which the continual afflux of decomposable matters exercises on the waters of a stream originally pure—an influence which the Commission have described, and have noticed in their examination of the state of the river. The system of sewers in Paris (which in 1856 were only 160 kilomètres in length) comprises at present 573 kilomètres of public sewers, and reaches (minor sewers included) 771 kilomètres. This vast network receives rain and the water from sinks, water-closets, and public urinaries, a portion of the sweeping of the streets, &c., &c.

The two outlets of Clichy and St. Denis discharge into the Seine a mean daily quantity of about 260,000 cubic mètres, or a little less than three cubic mètres per second; the fivesixths at Clichy (2·500) and the one-sixth at St. Denis (0·500), that is to say, a total quantity of 95 million cubic mètres of impure water discharged into the Seine per annum. This quantity will shortly reach 100 millions on the completion of the works of La Vanne. As has already been explained, this afflux of foreign matter forms shoals, and pollutes the river. Indeed, each cubic mètre contributed by the Clichy sewer contains on an average 1·28 kilogramme of solid matter, and at St. Denis 1·54 kilogramme; each year the Clichy sewer sends into the river 100,000 tons, and that at St. Denis 25,000 tons of solid matter, that is to say, 125,000 tons altogether. But the silting up of the bed of the river is not the only evil arising from those deposits: they contain from 10 to 25 per cent. of organic matter, in which there is from 4 to 6 per cent of nitrogen, which subsequently undergoes decomposition in the river. They contain besides only a fraction of the decomposable elements supplied by the intercepting sewers, for at Clichy the total sewage water (besides 1·28 kilogramme of solid matter) contains 0·82 kilogramme in solution, and the whole, which represents a weight of 2·10 kilogrammes per cubic metre, amounts to

	Kilogrammes.
Nitrogen	0·040
Volatile or combustible organic matter	0·660
Mineral matter	1·400
Total	2·100

At St. Denis the quantities of solid and soluble matter are respectively 1·54 kilogramme and 1·92 kilogramme, 3·46 kilogrammes in all, viz.

	Kilogrammes.
Nitrogen	0·140
Combustible or volatile matter	1·380
Mineral matter	1·940
Total	3·460

The influence of the drainage from the cesspits shows itself by a quantity of nitrogen three times as great as at Clichy.

and by a double quantity of volatile and combustible matter. From this will be seen the great increase in the pollution of the Seine caused by the departmental sewer; for although it discharges only one-fifth of the quantity of the Clichy sewer, it represents by its special impurity (shown by the quantity of nitrogen) the seven-tenths of this same sewer as regards the pollution of the river.

These figures will suffice to characterize chemically the two affluents which pollute the Seine below Paris. It may be also remarked that the total discharge of the river in summer being scarcely 45 cubic mètres per second, that is, only five times as much as the intercepting sewers, and the velocity of the Seine falling then to a few centimètres per second (13 in the summer of 1869) in consequence of the working of the barrages at Surèsnes and Bezons, the sewage of Paris is thrown, as it were, into a pool of stagnant water, with all the conditions most favourable to decomposition.

It would be unjust not to add that in the new conditions introduced into the flow of the Seine by the general use of *barrages* the pollution now experienced below Clichy would still be produced (even if the intercepting sewers had not been constructed) in Paris itself and in the wealthy suburbs of Sèvres, St. Cloud, Neuilly, and Courbevoie. The great intercepting sewers have then a healthsome effect in the most populous and closely built parts of Paris, they concentrate the polluted waters of the sewers without increasing the pollution, and they afford by this concentration, as will be shown farther on, the possibility of remedying the evils peculiar to themselves. It is absolutely impossible to imagine any efficacious remedy whatever which could be applied to the old system of drains discharging at numerous points on both sides of the river.

2°. *Secondary Causes, Small Sewers, Factory Water.*—On this subject attention has been drawn by several members of the Commission to the causes of pollution which still exist, even above the outlets of the intercepting sewers. These causes are certainly at present only of secondary importance compared with the considerable afflux from the sewers themselves, they do not produce very great pollution of the river, and the pumping stations for public supply can be used (without any practical inconvenience) at Choisy, at the bridge of Austerlitz, and at Surèsnes; but still, according to the researches made by M. Boudet, one of the Commissioners, a sensible diminution of aëration in the waters of the Seine has been proved to exist within the City itself, a corollary to the existence of no inconsiderable amount of organic matter; he found, in fact, in a litre of the Seine water the following quantities of oxygen:—

Above Paris.	Cubic Centimètres.
Above Corbeil	9·52
Below Corbeil	8·77
At the barrage of Évry	7·53
Choisy-le-Roi	7·52
Barrage at Port-à-l'Anglais	8·80
Bridge of Ivry	9·50

Organic nitrogen, 0·53 gramme per cubic mètre.

Through Paris.	Cubic Centimètres.
Bridge of La Tournelle	8·05
Viaduct of Auteuil	5·99

Organic nitrogen, 0·56 gramme per cubic mètre.

Below Paris.	Cubic Centimètres.
Bridge of Billancourt	5·69
Bridge of Sèvres	5·40
Bridge of Asnières	5·34

Organic nitrogen, 0·85 gramme per cubic mètre.

A diminution of oxygen is apparent towards Choisy-le-Roi; an increase after the fall at the *barrage* of Port-à-l'Anglais, then a progressive diminution through Paris and as far down as Asnières. The banks of the Seine, notwithstanding the immense benefit they derive from the intercepting sewers, are still polluted from the following causes:—

Above Corbeil, the factory waters of the Essone; above Paris, ten establishments such as starch manufactures, leather dressing, washing of felt and wool, dyers, chemical manufacturers, indian-rubber, *poudrette*, foundries, and six drains discharging the waters of the towns of Choisy, Maisons, Charenton, Vitry, and Ivry.

Through the City itself fifteen sewers not yet connected with the intercepting sewers, besides the sewers from the islands in the Seine, and the floating laundries—these last discharging every year into the Seine 176 tons of washing soda and 132 tons of soap.

Below Paris and down to Asnières ten sewers which drain the towns of Billancourt, Sèvres, Puteaux, Neuilly, Courbevoie, and Asnières, are often charged with factory waters, and one of them, formed in the old channel of Marivel covered in, throws on the right bank of the river the liquid from the night-soil depôt of the town of Versailles. From Clichy to St. Denis there are seven sewers (from Clichy, St. Ouen, and St. Denis) and fifteen manufactories of chemicals, soap, candles, gloves, glue, starch, tan-yards, &c. Finally, the Commission saw the polluted afflux which the Croult discharges at St. Denis after having served as the main sewer from numerous factories.

The Commission could not entirely ignore these secondary causes of pollution; if at present they leave the Seine comparatively pure above the intercepting sewers, their effects are in some degree lost sight of under the more prominent pollution of these sewers. If multiplied they will produce, to a limited extent, the evils which the Commission have described as existing below Clichy. Already their influence on the aëration of the water is felt within the bounds of the City itself. It is proper, then, to notice these secondary causes of pollution, and to apply to them (either directly or by connecting them with the intercepting sewers) the process of purification which the Commission propose to examine and discuss in the second part of this Report.

SECOND PART.

EXAMINATION AND SELECTION OF THE MEASURES TO BE TAKEN TO REMEDY THE POLLUTION OF THE SEINE.

Examination and Selection of the Measures to be taken: Principles.—The examination and selection of the measures to be taken to remedy the pollution of the Seine constitute the most important and delicate part of the work of the Commission. The interests concerned are indeed considerable. On the one hand, the City of Paris, with its two millions of inhabitants, should have all necessary facilities for sanitary improvement and for the prompt and free discharge of the *detritus* which such a large population daily engenders. On the other, it is not just to throw upon a single point in the suburbs all the filth discharged from the City of Paris; at least means should be sought for to alleviate, and even entirely to remove, those grievous consequences of the drainage of the City. The Commission, while adhering strictly to principle, should, in the examination of the question and the decisions they arrive at, use all the circumspection which the importance of the subject demands, and above all should confine themselves to facts and practical remedial measures. It is in this spirit that the question of the legality of discharging the intercepting sewers into the Seine has been shortly treated.

The Minister of Public Works in his letter to the Prefect of the Seine, dated the 22nd July, 1874, has himself pointed out that the law explicitly interdicts the discharge of filth into rivers or streams, and especially into the Seine. But although the strict letter of the law gives the authorities the power to intervene and issue strict prohibitory regulations, the practice generally tolerated in France is little in accordance with it. Almost everywhere manufacturers and corporations have regarded river-courses as receptacles for filth, and they conceive that care should first be taken of the industrial requirements and the internal salubrity of towns before enforcing too hastily new-fangled sanitary measures.

If, then, the weight of the facts proved in regard to the Seine should direct the attention of the authorities to the responsibility which falls on the City of Paris, and which is not repudiated, the Commission think that it is proper to generalize the remedies which are prescribed, to extend them, and to put them into execution with all necessary caution. Without stopping to discuss the strict law of the case, they lay stress upon the actual state of pollution existing in the Seine, in a populous part of the suburbs, in the neighbourhood of the pumping stations of St. Ouen, St. Denis, Epinay, Marly, Vésinet, St. Germain, and Maison Lafitte, and, concurring in the opinion given by the Council of the *Ponts et Chaussées* in 1870, they think that "the flow of the waters from the intercepting sewers of Clichy and St. Denis into the Seine causes an injury to the public health which the City of Paris is bound to remedy."

Raising of the Solid Detritus; Dredging; its Insufficiency as regards the Purification of the River.—In proceeding to examine the case under discussion the Commission, without prejudice to the more radical measures which will be examined farther on, must insist on the absolute necessity of continuing with vigour the removal by dredging of the mud with which the Seine is encumbered at the mouths of the intercepting sewers. Independently of the public health, this is a pressing necessity. It was stated in the first part of this Report that the intercepting sewers discharge into the Seine 150,000 tons of solid matter in the year, that is to say, a volume of liquid mud of from 200,000 to 300,000 cubic mètres; the heavier particles form banks, which emerge periodically, and which have been dredged by the Navigation Service for some years in the following quantities:—

	Cubic Mètres.
1868	69,000
1869	58,000
1870	57,000
1871	64,000
1872	66,000
1873	82,000

In 1874 the City authorities allocated a sum of 180,000 francs for dredging at the mouths of the intercepting sewers; but these operations, executed on the top of mud banks, and removing besides a less quantity than that supplied by the sewers, could not prevent the accumulation of shoals, the progressive fouling of the bed of the river by mud and light organic matter, and the extension and annual increase of the phenomena of fermentation even in the deepest part of the stream, polluted to the surface by soluble fermentable matter. The Commission can only regard dredging in the light of a temporary remedial measure; and in no case can it be viewed as a solution of the question.

Different Projects proposed for the Purification of the Seine; Objections to them.—The Commission can do no more than allude to some of the projects proposed, the names of which alone will show their worthlessness.

1°. *Prolongation of the Intercepting Sewers to the Tidal Part of the Seine or to the Sea.*—This project will, at great expense, simply remove the pollution to a point on our coasts.

2°. *Prolongation of the Intercepting Sewers to the Confluence of the Oise.*—The addition of the discharge of the Oise will only spread and displace the pollution without destroying its predominant cause, that is to say, fermentable matter.

3°. *Dilution of the Sewage Water in the Interior of the Sewers, or at their Mouths by Clear Water.*—The dilution would simply have the effect, as above, of spreading the pollution over a larger area. This scheme, like the two preceding ones, would not permit, besides, any utilization, for agricultural purposes, of the fertilizing matters contained in the sewage water.

4°. *Filtration of the Sewage through different Substances.*—This operation always gives an incomplete result; solid clayey matter and matter in solution pass through the filters. These require constant repairs, and with their basins constitute a serious danger to the public health; the operation is also costly, especially in the item of labour.

5°. *The Construction, at the Mouth of the Intercepting Sewers, of large Settling Basins.*—It would be necessary to make these basins of very large dimensions, and consequently to create vast centres of pollution; purification by the simple process of settling would be most imperfect, and the handling of the deposit would present great difficulty.

Purification by Chemical Processes, and especially by Sulphate of Alumina; Insufficiency and great Cost of the System.—The objections already made apply, at least in some degree, to the different systems in which the precipitation of solid matter is hastened by the addition of chemicals. Sewage water containing various mineral or organic matters, which give generally an alkaline reaction, favour chemical operations, of which they become one of the elements; if a gelatinous or flocculent precipitate is produced, it falls to the bottom of basins suitably arranged, dragging with it the solid matter contained in the impure liquid, leaving the comparatively pure water to escape by an overflow on the down-stream side. By the advice of M. Le Chatelier, Inspector-General of Mines, the City authorities have made prolonged and numerous experiments on sulphate of alumina, which seemed to present greater practical advantages for the purification of sewage water than quicklime and other reägents already known in France and England. The first settling basins were established at Clichy, and were in action in 1867–8. Others, larger and of better construction, still exist in the plain of Gennevilliers on the Paris clay. On the 11th October the Commission saw the basins at work, and the water which flowed from them was perfectly clear. 600,000 to 700,000 cubic mètres of sewage water were submitted at different times to this mode of treatment and issued pure from the basins. But it was a great error to mistake water thus clarified for really pure water. Sulphate of alumina, after having been decomposed by the alkaline properties of the sewage water and having passed into a state of granulated gelatine, simply effects a mechanical clarification: the solid matter falls to the bottom of the basin; the soluble matter (including fermentable organic matter) remains in the clear water. Chemical analysis abundantly demonstrates this fact. The following table is a *résumé* of the analysis made in the year 1867–8:—

	Sewage Water.	Water purified by Sulphate of Alumina.
	kilogrammes.	kilogramme.
Nitrogen	0·037	0·021
Volatile and combustible matter ..	0·729	0·240
Mineral matter	2·038	0·724
Total	2·804	0·985

The clarified water contains, then, two-thirds of the total nitrogen in the sewage water, and one-third of the volatile or combustible matters, which are mostly organic. These facts are not applicable alone to sulphate of alumina. Dr. Frankland (employed by the British Government to make a general Report on the pollution of rivers) having submitted to analysis different reägents tried or proposed, has found that on an average they extract from sewage water only 37 per cent. of the organic nitrogen contained in it, leaving 63 per cent. thereof in the clarified water. It is proper to add that as to the purifying properties of sulphate of alumina it usually contains an excess of sulphuric acid, which acts as an antiseptic, retarding fermentation, and that the clarified waters no longer present the intense decomposition observable in sewage water in its natural state, but they are still far from being suitable to the most simple domestic uses, they have in no degree the character of potable water, and their introduction into the river in this state, while it is an amelioration of its present condition, cannot be considered as absolutely harmless. Besides, applied on a large scale, this process leaves an enormous deposit of filth in the basins. It is to be remembered that the annual quantity of sewer mud is not less than 200,000 cubic mètres; fancy, then, this enormous quantity drying on many hectares of superficies, and loaded afterwards in carts or boats. Have these deposits a high agricultural value? Not at all; one thousand kilogrammes contain only six to eight kilogrammes of nitrogen, lost in a mass of mineral and earthy matter. Long experience has shown that these deposits have the same value as good farm-yard manure or night-soil, to which they are very similar; the market value of these manures, delivered on the ground, scarcely exceeds six to eight francs per ton. But what will the same quantity of the residuum of the basins cost? In chemicals alone there will be spent six to eight francs, that is to say, their full value, without counting the cost of pumping, the manipulation of the deposits, carriage, &c., operations which will greatly increase the expense. The question of cost alone will be sufficient to prevent the thought of seriously attempting to apply the system to the entire quantity of sewage water to be dealt with. Long experience at Paris does not permit the hope that the expense of purification will be less than one franc for every 100 cubic mètres treated; this, then, gives an expenditure in chemicals alone of one million francs for 100 million cubic mètres discharged by the intercepting sewers; all the other expenses remain to be added for pumping, &c. Such an expenditure is out of all proportion to the imperfect result obtained. The Commission, then, have unanimously resolved that purification by chemical processes cannot constitute a general and practical solution of the question. They cannot regard it in any other light than that of a dear and imperfect palliative. They will examine in the sequel whether in some particular cases chemical clarification cannot render some service accessory to the really complete purification of impure water.

Purification of the Seine by the combined Action of the Soil and Vegetation; Irrigation by Sewage Water.—It is in the combined action of the soil and vegetation that in the opinion of the Commission the true solution of the question will be found. By irrigation applied to a permeable soil sewage becomes not only inoffensive, but productive and fertilizing. Sanitary conditions are satisfied, and at the same time there is gained for agriculture a source of manure hitherto absolutely allowed to run to waste. The conviction which the Commission have unanimously arrived at on this point seems justified by the considerations and remarks following.

Principles and Theory of the System.—When impure water, charged at the same time with matters in suspension and solution, is discharged on a permeable soil, the upper bed of earth commences to act as a filter, all the matter in suspension is separated by simple mechanical action. Without going beyond the laboratory, the Commission have been able to prove at the municipal office at Clichy that a large cistern 2 mètres in height, or even a simple glass jar of half a mètre, filled with earth and coarse sand from the plain of Gennevilliers, was sufficient to clarify completely, and for an entire month, water highly charged with sewage poured upon the surface. The great phenomena of permanent filtration which certain soils present are well known. As an example, the alluvial land of the *Pays de Caux,* where mud 5 or 6 mètres thick overlying a bed of dislocated chalk has never hindered the constant permeability of the soil. After this superficial mechanical filtration the waters (clarified by passing through the upper beds of the soil) reach the roots of plants, which absorb, with benefit, the fertilizing substances which remain still in a state of solution, and give to the waters, notwithstanding their brightness, a real impurity. If we seek by the aid of analysis to ascertain the quantity of sewage water necessary to furnish to the plants of the kitchen garden the elements essential to a good crop, such as nitrogen, the alkalies, or phosphoric acid, it will be found to be about 15,000 cubic mètres of sewage water to each hectare, and to produce three crops 45,000 cubic mètres of sewage water at the least, without counting waste and the quantity absorbed by parasitical plants. This quantity of water is thus deprived, with benefit to agriculture, precisely of those elements which most affect the purity of the water. In cases where the land is not so highly cultivated, and where absorption by vegetables is not so continuous, the soil itself retains, during the passage of the sewage through it, the greater part of the fertilizing elements; 80 per cent. of carbonate of ammonia, 74 per cent. of carbonate of potash, &c. Finally, as to the waters which have escaped the absorbent action of plants or the retentive action of the soil—continuing their descent where the subsoil is either naturally or artificially permeable, they undergo in the beds of this subsoil an oxidizing action which acts powerfully on the azotic matter contained in them, which change from the state of organic substances into that of nitrates or nitrites, substances purely mineral, presenting no longer any danger of fermentation, and absolutely harmless when diluted with a sufficient quantity of water. Thus chemical analysis has shown that water, issuing from the experimental apparatus before described, no longer contains any sensible trace of decomposable nitrogen, notwithstanding that previous to passing through the soil it contained a total quantity of 43 grammes per cubic mètre of nitrogen, nor was there found in it on an average more than 1·6 gramme of nitrogen in the state of mineral ammonia, being the same quantity which the water of the Seine contains above the contaminating influence of the intercepting sewers. It should be stated, on the other hand, that where no vegetation exists on the surface, a quantity rising as high as 41 grammes of nitrogen per litre has been obtained.

The movement of descent through a porous soil ensures even to the affluent water a satisfactory aëration. Sewage water thrown on the surface of the soil in the Clichy experiments contained hardly 2 cubic centimètres of oxygen to the litre; it issued from a bed of stony earth of 2 mètres thick, with from 7 to 10 cubic centimètres. It is in this state of complete revivication that the sewage water, now *purified*, and not merely *clarified*, joins the subsoil waters, and flows into the drains when they have been made through land sufficiently permeable. The English Commission on the pollution of rivers have arrived at the same conclusion, thanks to the learned researches of Dr. Frankland.

Operations carried on by the Authorities of the City of Paris in the Plain of Gennevilliers.—The Commission have attentively examined the proceedings taken by the City of Paris for realizing practically, and on a large scale, the phenomena described. Repeating and extending the experiments made in 1867–8 by Inspector-General Mille at Clichy, the City engineers commenced in the month of June, 1869, the irrigation of the plain of Gennevilliers.

The sewage water is raised at Clichy by centrifugal pumps, which, from the absence of valves, have the advantage of permitting the free passage of solid bodies carried by the current of the intercepting sewers. Steam engines of 40 H.P. in 1873, and at present of 150 H.P., drive the pumps, which raise the water to the height of about 11 mètres into cast-iron pipes (from 0·60 to 1·10 mètre in diameter) which reach the plain of Gennevilliers, passing under the footways of Clichy bridge. On the side of the departmental sewer a conduit in masonry (1·60 mètre high by 0·90 wide at its commencement) has been built between the gate of La Chapelle and the bridge of St. Ouen; the inclination of the surface is sufficient to convey through this conduit, by the action of gravity alone, all the sewage from this side of Paris for a length of 3300 mètres. The Clichy engine can pump constantly half a mètre per second, or 44,000 cubic mètres per day. The St. Ouen conduit can discharge, if necessary, the same quantity. The sewage waters from those two sources now unite in a long brick drain, 2 mètres wide and 1500 mètres long, erected on the embankments of Asnières and Gennevilliers. A conduit lined with masonry 0·60 mètre in diameter and 1950 mètres long, a brick drain 1·20 mètre wide and 2250 mètres long, and 15 to 20 kilomètres of surface drains, complete the system of distribution. This system commands a surface of 143 hectares of land capable of being irrigated. The sewage water has been applied to 115 hectares since the 1st of October last. The distribution of the sewage is effected by furrows separated by ridges of different widths. In the open plain these furrows are made by the plough; in garden lots by the spade and line. Plants shoot up on the ridges, their roots alone seek moisture and manure from the drains; the green part of the plants is never touched by the sewage water. In autumn and winter lumps of manure partially submerged are warped on the lands, but most frequently the manuring is effected by moulding or by absorption. The quantities of sewage water absorbed by the earth in the plain of Gennevilliers have reached since 1869 to more than 18 millions of cubic mètres.

	Cubic Mètres.
1869	650,000
1870	810,000
1871 (War and Commune)	..
1872	1,500,000
1873	7,200,000
1874	8,000,000
Total	18,150,000

The annual quantity applied to each hectare varies from 50,000 to 100,000 cubic mètres.

Settling basins on land belonging to the City of Paris were established in 1869; after having clarified in that year 320,000 cubic mètres, and, in 1870, 97,000 cubic mètres of sewage water, the basins have not been worked regularly; since the system of irrigation has been adopted they are only used experimentally. The deposits collected from them have been used for top dressing, and in the removal of the night-soil from Paris; a part of the dredgings from the Seine has been added to the deposits, and now replaces them for agricultural purposes. The Navigation Service has thus deposited on the municipal lands—

	Cubic Mètres.
1871	24,000
1872	18,000
1873	13,600

These deposits are rented by a dealer, who usually pays a yearly sum of 1000 francs to the City, and retails them at Colombes, Chatou, Le Vésinet, and other localities on the banks of the Seine.

Results obtained at Gennevilliers.—The Commission have examined (as well from a sanitary as an economic point of view) the results of the operations, the principal features of which they have now sketched. They have in the first instance shown how well the soil of Gennevilliers is adapted to the purpose. These soils are in fact formed of a vast bed of alluvium, from 7 to 10 mètres in depth, formed by the Seine; this alluvium is composed of sand and gravel, covered generally by a thin bed of vegetable earth. It is below this permeable mass that the beds which hold the infiltrated waters lie; these form a vast subterranean sheet, descending from the heights of Mount Valérien and Buzenval towards the Seine, and lying between 2 and 4 mètres below the surface of the soil. The plain of Gennevilliers constitutes an immense natural filter, eminently adapted to absorb and purify impure waters.

The Commission have practically verified these theoretical opinions. They have seen on the sides of open quarries in the plain a thin bed of arable earth, under which they found banks of sand, flints, and gravel, which preserve their natural colour without showing the least trace of the black deposit of organic matter, a positive proof that the superficial bed acts well as an efficient filter of the muddy waters poured on the irrigated lands. The Commission have caused water to be drawn from wells sunk in the middle of the irrigated lands: this water was perfectly clear, identical in appearance, as well as in taste, with the sulphatic waters of the subterranean sheet which supplies the wells of the whole plain between Rueil, Courbevoie, and the Seine. They have made an examination of the waters flowing from a drain in a part of the experimental garden of the City of Paris into the Seine. Those waters submitted to chemical analysis have been found perfectly free from fermentable matter.

	Organic Nitrogen per cubic mètre.	Total Nitrogen to the cubic mètre.
	gramme.	gramme.
Well-water from the City garden	0·10	0·30
Water from the drain ..	A trace.	0·35

These waters are more pure than those of the Seine above the intercepting sewers, which contain 0·85 gramme of organic nitrogen and 1·05 gramme of nitrogen altogether. They are even superior to those similarly taken from wells situate in the same bed of water (but outside the area irrigated) in lands naturally less permeable, and less adapted to oxidation; they are similar in chemical purity to the water of the springs of Arcueil. This is shown by the following figures, corresponding to the neighbouring wells at the stations of Courbevoie and Colombes and to a sample of water from Arcueil.

	Organic Nitrogen.	Total Nitrogen.
	gramme.	gramme.
Wells of Courbevoie	0·23	0·77
Wells of Colombes	0·23	0·83
Water from Arcueil	0·05	0·43

The water from the drain presents even a superior aëration to that of the Seine above the intercepting sewers, viz. 6 to 6½ cubic centimètres per litre. In the wells, when the water is still, the quantity of oxygen is less (2 to 3 centimètres). It is the same, whether in the environs (wells at Asnières 3·6, Clichy wells 1·0 to 4·6), or at St. Denis (2·4 wells at Gonesse, 3·0 Aubervilliers, &c.).

The Commission can therefore only bear testimony to the actual and evident action of the soil of the plain of Gennevilliers; they do not think besides that this action can be stopped after some time by the filtered matter. The grand phenomena of natural filtration, and especially those of the *Pays de Caux* before cited, permit the belief in a constant permeability, even after the formation of mud many mètres in thickness; but the average bed of deposit effected by the irrigation operations at Gennevilliers does not reach ·001 mètre per annum. The deposits (as the Commission have proved *de visu*) are not foul or dirty; containing 50 per cent. of siliceous matter, they are friable and permeable. The operation of tilling incorporates them each year with the soil, and the result is simply a maintenance or increase of a bed of light arable earth. This process of absorption of the waters, the incorporation of the deposits with the soil, and its utilization by plants, guarantees at the same time the salubrity of the surrounding locality. The water does not rest anywhere, and the phenomena of fermentation and oxidation take place in the bosom of the earth, instead of being produced in the Seine.

The Commission have seen around the municipal lands where the operations commenced in 1869 quite a village recently built. No special disorder has appeared in this village, called Gresselons, and the daily increase of this rising locality (in the midst of fields where the sewage water circulates) is the best proof of the harmlessness of the system. Some quarrymen have maintained that the level of the sheet of water which was always met at a small depth beneath the soil had risen since the irrigations. These complaints originated at the time of the inundations of 1872–3, when the irrigation works were not in operation; they rest alone on a fact purely mechanical, and do not touch in any way even the principle or the hygienic result of the operations. It is a matter of detail which is for the consideration of the agents of the City of Paris, and which it will be easy to remedy by some drains if, contrary to the actual facts of the case, such a rising is produced in a permanent manner.*

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* By a letter addressed on the 31st October, 1874, to the Minister of Public Works, and referred to the Commission, MM. Pommier and Co., manufacturers of chemicals at Gennevilliers, reiterated these complaints. MM. Pommier supplied sulphate of alumina to the City authorities for the experiments of purification by chemicals. In a petition attached to their letter, but having no other signatures, they forcibly insisted upon the advantages which, in their opinion, the system of chemical purification offered. They acknowledged what is true, that "the sewage waters had fertilized the plain of Gennevilliers," but they pointed out in general terms the inconvenience and dangers which the system of irrigation presented, and they specially insisted upon a pretended inundation of cellars and quarries. The Commission can only refer to the

As to agricultural and economic results, the Commissioners have witnessed the prosperous state of the irrigated lands; they have seen in several parcels of land, and specially on lands belonging to the municipality, comprising 5 to 6 hectares, let to different manufacturers, the most varied produce, from vegetables of all kinds to flowers and fruits. In the soil of this plain the cultivation of vegetables is predominant; fields of cabbages and artichokes specially attracted the notice of the Commission. A certain number of fields are reserved for plants used in manufactures, among which were to be seen peppermint, distilled in the neighbouring factory of a perfumer, M. Chardin-Hadancourt. Within the limits of the irrigated area the large farmers employ the water as manure, or for watering in summer, rye, cut green, mangle-wurtzel for cattle, vegetables, and lastly some meadows bordering the Seine are irrigated. The lucern grasses in the month of October, when the Commissioners visited the lands, were still growing freely, and had been cut four or five times. The mangle-wurtzel was cultivated for sale, and produced nearly 100 tons per hectare.

According to the information furnished by the municipal engineers, the rent value of the lands irrigated has sensibly increased since their reclamation: from a value of 90 to 120 francs per hectare they have risen to 200, 300, and even to 400 francs. The lands belonging to the City are let at the rate of 5 francs per 100 square mètres, or 500 francs per hectare. These facts explain how, as the City extends the conduit and drains, the farmers use the sewage placed at their disposal. It is thus that the irrigated

considerations enlarged on in the body of the Report. If the irrigations cause damage, well and duly proved, the persons injured have always (as in the case of any public work) the right to appeal to the proper public tribunal for redress. Private interests cannot, and should not, be allowed to stop a work necessary to the public health, and loudly called for by the riparian inhabitants. Two petitions, from the manufacturers of Clichy, and the Town Council of Epinay, have likewise been referred to the Commission.

surface has progressively increased, as shown in the following table :—

		Length of Drains and Main Conduits beyond the Municipal Lands.	Surface to which the Sewage is applied. (Hectares.)		
		kilomètres.	h.	a.	c.
1869	.. ..	..	6	38	82
1870	.. ..	..	21	82	73
1871	.. ..	War and Commune.			
1872	July	2·770	45	41	32
	November ..	3·877	51	17	52
1873	May	4·000	62	03	92
	December ..	5·700	88	35	42
1874	— August	5·700	115	52	60

This area of 115 hectares corresponds actually to 143 hectares, capable of being irrigated by the system already established. There is every reason to suppose that irrigation will be extended at least in the same proportion as the arterial distributing drains are pushed farther on. The Commission think it right further to insist upon the fact that the progressive development of irrigation is due to the free operation of private enterprise, without the interference of the City authorities, either by coercion or appropriation of the land.

From the actual state of facts at Gennevilliers, as well as from theoretic considerations, the Commission have arrived at the conclusion that the sole remedy for the pollution of the Seine by the water of the intercepting sewers consists in the employment of these waters for agricultural purposes, and that the system practised on a permeable soil such as the peninsula of Gennevilliers and applied to garden culture or to meadows will permit of prolonged cultivation without any risk to the health of the locality.

Application to the Total Discharge from the Intercepting Sewers.—The Commission, relying on the facts stated and the principles which naturally flow from them, have thought it right to ascertain how the operations now being carried on at the commencement of the plain of Gennevilliers could be extended and applied to the total discharge of the intercepting sewers. The members who specially represented the municipality of Paris have furnished the following particulars:—

A sum of one million francs voted the 2nd March, 1872, supplied the means for the present establishment.

	Francs.
The conduit between La Chapelle and St. Ouen (departmental sewer), and between the Clichy sewer and the pumping station	453,000
The first division of the pumping station, comprising purchase of land for the entire station, *prise d'eau* in the Seine, &c.	381,000
Cast-iron conduits for crossing the Seine at the bridges of Clichy and St. Ouen	166,000
Total	1,000,000

With the aid of a like amount voted in 1874 (applicable to projects approved by the Municipal Council at their meeting on the 5th and 20th November, 1874) there will be forthwith executed in the district of Gennevilliers a complete network, comprising 10,910 mètres of culverts in masonry, varying in diameter from 0·60 to 1·25 mètre, which will carry the sewage to any part of the plain lying between the Seine and the depression in the surface of the land called the Ditch of Aumône, extending almost in a right line from Clichy to Argenteuil. These works are estimated at 750,000 francs. The surface within the boundary indicated is from 1200 to 1300 hectares, in which may be reckoned 1000 hectares available for irrigation after deducting waste, houses, roads, &c. These 1000 hectares will require (as practically determined) fifty million cubic mètres per annum, that is, about one-half the total discharge of the intercepting sewers.

This fifty million cubic mètres will be furnished by the conduit of St. Ouen, by the 150-H.P. engine at Clichy, and by a new engine of 250 H.P., the price of which, including the necessary buildings, will amount to 250,000 francs, and which, with 750,000 francs to be expended in the main distributing conduits, will absorb the vote of 1874. The system will be complete by the erection of a brick chimney at a cost of 25,000 francs to replace the temporary one of sheet iron; by the construction of a complete line of pipes of 1·10 mètre in diameter between the engine-house and Clichy bridge, where the work is now performed by the old pipes of 0·60 mètre in diameter (90,000 francs); and finally by secondary works of distribution in the plain, estimated to cost 500,000 francs.

There will be thus a sum of 615,000 francs to be provided for in the estimates of 1875, or from funds to be raised by the projected municipal loan. The whole works, representing a total expense of 2,615,000 francs, will secure a daily service of from 1500 to 1700 cubic mètres, which is between the half and three-fifths of the total quantity delivered by the intercepting sewers. The sewage diverted from the river will be conveyed to Gennevilliers and applied to the irrigation of 1000 hectares, according to the principles and practice now in operation.

The Commission learn, with satisfaction, from the City authorities, that the greater part of the necessary funds have already been provided, and that the perfect purification of the river may now be considered certain, at least to the extent of half of the sewage delivered by the intercepting sewers.

The Commission have then to consider the other moiety of the sewage, the removal of which will alone resolve completely the question of the purification of the river.

The municipal engineers have pointed out that the plain of Gennevilliers stretched towards the east beyond the Ditch of Aumône towards Colombes, Nanterre, and Rueil; that these lands (all lower than the bridges of Clichy and St. Ouen, and consequently capable of being irrigated) are equally suitable for applying the system proposed for the plain of Gennevilliers; that between the inhabited parts, such as Colombes, Nanterre, and the Seine, the surface which can be irrigated is from 1000 to 1200 hectares, and is suitable, as well from its natural configuration and geological properties as by its tillage, to the absorption and utilization of the remaining half of the sewage; that an expenditure of 2,385,000 francs, bringing the entire expenditure up to five millions of francs, necessary for the purification of the Seine, seems sufficient for the work; that three new steam engines (including one spare one) would be required (750,000 francs); a new chimney and new pipes (115,000 francs); new masonry conduits (75,000 francs); secondary works for distribution (500,000 francs); and finally, 270,000 francs for sundries.

In consequence of these explanations the Commission agree with the representatives of the City that the second part of the works seems as practicable as the first, but that it will evidently require some time to accomplish it. The works (properly so-called), the steam engines, buildings, and pipes, can evidently be executed with little delay, and the municipal engineers have produced to the Commission a programme according to which the whole of the works, both principal and secondary, will be completed in a period of five years. But in a work of such importance it is always necessary to count on unforeseen delays. Although the City of Paris offers the sewage gratuitously to the farmers, although the results already obtained actually demonstrate by the most powerful evidence the agricultural value of the sewage, and the increased value which it gives to the lands, the habits of the farmers, or even of certain other respectable classes, will cause less or more delay in the development of irrigation, which solely constitutes, after all, the means of purifying the Seine.

Purification by Chemical means as a part of this System.—From this point of view, and as a temporary measure, the Commission have considered if purification by chemicals could not be used at least for the clarification of sewage not applied to irrigation; but the considerations already given have caused them to abandon the idea as imperfect and costly. It must be remembered that its application to the whole of the sewage would entail an annual expenditure of 1,000,000 francs for chemicals alone; for half the quantity the cost would be 500,000 francs, or an annual sum equal to one-tenth of the total sum necessary for irrigation. It is evidently better to apply this sum to a definite and rational solution of the question, and to hasten it as much as possible. The works for the utilization of half the sewage were in course of erection in 1874 and 1875, and already the pollution of the river is considerably diminished. The Commission have thought it better to encourage the City to pursue with energy purification by application of the sewage to the land than to embarrass them in illegitimate and costly solutions, the urgency of which will be evidently diminished by the constant progress of irrigation.

In case of necessity chemical purification can be practised at the commencement or end of the main arteries of distribution when the inclemency of the season or the necessities of agriculture leave unemployed a fraction of the sewage raised by the engines; but such an application will always be essentially intermittent and restricted.

Extension of the Works to the Government Lands in the Forest of St. Germain.—The Commission entertained with much favour an idea originated by one of its members. He observed that there existed in the Forest of St. Germain 1000 to 1200 hectares of Government lands of little value. These lands are situated near the Seine and at a level of 30 mètres of elevation, which is also that of the plain of Gennevilliers. They present excellent conditions for the absorption and utilization of sewage water, which can be sent to them by works which seem to present no very great difficulty. The State and the City of Paris could enter into an agreement which would regulate their respective rights, and would secure an equitable distribution of the benefits which would be certain to result from the works.

The second half of the sewage (the other being always appropriated to Gennevilliers) would find there a field of application absolutely free and immediately available; the operations at Gennevilliers would be at the same time facilitated. Knowing that the City of Paris could pass them by, and refuse the sewage which they now freely offer, the farmers would without doubt solicit as a favour, and pay for the irrigation, which they now too often accept with a bad grace, at least in appearance.

The Commission have been much struck with these considerations, and they consider it right to recommend the investigation of the question to the immediate attention of the City engineers. If, after full inquiry, the practical possibility of the scheme be demonstrated, it should be obviously undertaken in order to hasten the purification of the river.

Provision for Government Intervention in case of the Stoppage of the Works by the City of Paris.—The Commission must very strongly insist upon the urgency of a complete solution of the question. If from the considerations already stated they have unanimously agreed that it is just to allow a reasonable time to the City authorities to complete the works, they are equally unanimous in holding firmly to the principle of the obligatory purification of the Seine. The Government will ascertain the progress made in this respect, and will take into account the difficulties and the considerable expense of the work; but, in the improbable case of the works being delayed for want of funds being allotted for them, the Government will reserve the right to demand the completion of the works necessary for the purification of the river.

Measures for the Removal of the Secondary Causes of the Pollution of the Seine.—It only remains for the Commission to discuss a question which has been mentioned in the first part of this Report, and the examination of which has been rendered easy by the particulars already given; it is that of the factory waters, night-soil, dye works, various manufactories, &c., &c., as well as the sewers adjoining the river, not yet connected with the intercepting sewers.

Manure Depôt at Bondy; Removal from the Seine of the Liquid from Night-soil.—Among those impure waters the most important, without any doubt, are those which flow from the manure depôt at Bondy, and which actually cause the special pollution of the departmental intercepting sewer discharging into the Seine at St. Denis. There is in Paris (*Route d'Allemagne*) a depôt for night-soil, in which is thrown all the feculent matter which the night-men (*vidangeurs*) do not carry to their respective depôts. From this depôt (*depótoir*) it is carried by a conduit to the Forest of Bondy, where the municipal depôt is established. Up to the year 1870 it was rented by the *Richer* Company (now Le Sage and Co.). Since then the liquid manure, after having undergone certain treatment at the depôt, flows to the Seine by a return conduit and the departmental intercepting sewer. The imperfect process to which it has been subjected allows half of the nitrogen to reach the Seine.

In 1872 the depôt at Bondy was taken by an English Company at public auction; after having spent five million of francs in the speculation they ceased work altogether. The night-soil from the depôt in Paris, in place of being conveyed to Bondy, is carried directly to the Seine by the return conduit, and causes the great pollution experienced at St. Denis. The Commission protest against such a state of things, and inquire whether a prompt remedy cannot be applied. It is certainly not their province to advise as to the procedure to be adopted by the City of Paris to effect the removal of night-soil from the houses, or to make use of it in manufactories; these are matters which are under the control of the municipal police. They have, however, listened with much interest to the explanation given by a member of the Commission (the director of the water and sewers of Paris). They rely upon his promise to substitute filter-tubs or shoots for the present barbarous system, and they have learned with satisfaction that in the manufactories of M. Le Sage and Co. the night-soil has been treated in close vessels, and sulphate of ammonia or *poudrette* has been produced without giving place to the inconveniences hitherto experienced at Bondy.

But the Commission return to their proper duty in seeking means to remove from the Seine both night-soil and the liquid manure discharged from manufactories where these matters are subjected to treatment. In this case they have found in their employment for agricultural purposes the same advantages which they have already recognized in respect of sewage water. It is useless to reiterate the principles before stated, especially as practice has now confirmed the opinion of the Commission.

Up to 1872 a quantity of feculent matter was taken by certain farmers from the depôt at Bondy (which in the year 1869 reached 16,000 cubic mètres), and which they applied with advantage to their lands. At the present time Le Sage and Co. have added to their recently-erected manufactory at Choisy-le-Roi a farm of 136 hectares. On this farm they apply by improved agricultural methods, either the matter in its natural state or the liquid manure from the works. The employment of both, when they can be mixed with sewage water, is most simple and economic; but this is an easy matter in consequence of arrangements made by the City of Paris for diverting the waters of the departmental sewer from the river. This sewer passes in fact in Paris at a short distance both from the night-soil depôt and the return conduit from Bondy; it will therefore be an easy matter to connect them, whatever method be taken, when the work is resumed at Bondy. These night-soil waters (*eaux vannes*) will be carried by the conduit from St. Ouen, by the effect of gravity alone, to the plain of Gennevilliers, where they will be distributed at the same time as the sewage water, when the projected works at that side are completed. It is a work which presents no serious difficulty, and the Commission particularly recommend that it should be among the first commenced.

Industrial Establishments and Secondary Sewers.—As to the different industrial establishments and secondary sewers which still discharge their waters into the Seine, the Commission see no reason why the principles already explained should not be applied to them also. If, from long neglect, the law, especially that of 1777, has been allowed to become a dead letter, if in the absence of practical and simple measures of purification the authorities have hesitated to impose prohibitions which they would have scarcely known how to enforce, it would appear that the facts already established, and especially the great experience at Gennevilliers, will now permit a more strict application of the law.

It is scarcely necessary to add that a simple surveillance of the banks of the Seine will prevent the direct discharge into the river of solid *débris* and the dead bodies of animals. In a great number of cases the generalization of the system of intercepting sewers will allow of the closing of the mouths of the secondary sewers still discharging into the Seine. For example, the City authorities intend to abolish by two intercepting sewers parallel to the Seine, the sewers of Grenelle, Auteuil, the Quay of Austerlitz, and Bercy ; and by syphons those of the isle of St. Louis. It is desirable that similar works should be undertaken in the suburbs to intercept the impure water from the Seine ; the sewage can then be treated in the same manner as already described for the intercepting sewers of Paris.

When the industrial establishments are isolated and cannot send their liquid manure into the nearest public sewer, there is nothing to hinder them from employing the economical methods to which modern science leads, especially the agricultural system of purification ; in the *Département du Nord* this has been already done in some cases. It was recommended in 1859 (in combination with drainage in the case of impermeable soils) by M. Wurtz in a remarkable Report on the residuum from a distillery. M. Dailly has thus treated the residuum from his distillery at Trappes. M. Gerardin has also employed the action of drained soil for purifying the residuum of starch factories and other industrial establishments at Gonesse, Aubervilliers, and Choisy. The English Commission on the pollution of rivers have arrived at the same conclusion.

On the whole, the combined action of the soil and vegetation presents the complete and rational solution of the purification of rivers.

By such a procedure the substances injurious to public health are transformed into sources of agricultural wealth; not only evil disappears, but good results; health is preserved, agriculture profits, and the great natural law of restitution is satisfied.

Summary and Conclusions arrived at.—The considerations and observations contained in this Report have led the Commission to the following conclusions

As to the actual State of the Seine.—1°. A simple inspection of the actual state of the river leads to the following results:

Above Paris the waters of the river are generally in a sufficiently pure state.

Through the City, and below it as far as Clichy, the pollution of the river by the discharge of water from manufactories or drains is at present little felt; but from the intercepting sewer, which discharges at Clichy, the water flowing along the right bank suddenly passes into a state of repulsive pollution, and this state is considerably increased (from St. Denis to the end of the island of that name) by the fetid waters which flow from the departmental sewer charged with the liquid manure from the depôt at Bondy, and the manufactories at Aubervilliers and St. Denis.

This pollution of the waters by the discharge of the intercepting sewers, which is strongly marked within the limits indicated, extends also, but in a less degree, to the left branch.

From Argenteuil the pollution of the waters decreases very rapidly, it is still sensible at Marly, and only disappears completely below Meulan.

There exists in the bottom of the river, below the mouths of the intercepting sewers, deposits of polluted matter in a state of fermentation, which are continually giving off bubbles of carbonated and sulphuretted hydrogen; these bubbles, generally very small, are in summer often of considerable size, about one mètre in diameter.

The dredging executed by the Navigation Service for raising this deposit, at such times as it can be carried on without becoming itself a nuisance, is insufficient for its removal, and it is annually increasing in volume.

2°. Independent of the muddy state of the waters, which is obvious, their pollution is characterized, on the one hand, by the proportion of fermentable matter which is in suspension and solution; and, on the other, by the proportion of free oxygen which they hold in solution.

From the experiments mentioned in the Report, the waters of the right branch (from the mouth of the Clichy intercepting sewer to the extremity of the isle of St. Denis) must be considered unfit for the use of man or animals, for culinary purposes, or other domestic uses, and even for the washing of the streets without previous settlement or purification.

From Argenteuil to Marly, and below it, the water is less impure, and is in a great measure applicable to the wants of the inhabitants on the banks of the river. Although not unfit to drink, it has still an insufficient aëration, and contains a considerable quantity of azotic mineral substances.

Below Meulan and Mantes the waters of the Seine, having become free from the contamination of the sewers of Paris, and having received a fresh supply of oxygen from the atmosphere, are fit to drink and for domestic purposes.

MEASURES TO BE ADOPTED.

1°. Generally—To prohibit in the first place, by the application of the Royal Ordinance of the 20th February, 1773, and the Order in Council of the 24th June, 1777, the emptying into the Seine, water, filth, or excrement of any kind which would render its waters unwholesome or unfit for domestic use.

2°. To prevent the pollution of the Seine by the water of the intercepting sewers, the most economical, practical, and efficacious means of doing which consists in using them for the irrigation of a sufficiently permeable soil. Different kinds of tillage (above all, that of kitchen gardens) will find in these waters the moisture and manure necessary for them.

The experiments made in the plain of Gennevilliers are entirely conclusive, in showing not only the luxuriant vegetation produced by the irrigations, but also their harmlessness in respect of health, as well as the perfect purification of the waters which return to the river after having traversed a subsoil naturally permeable or sufficiently drained.

It has, besides, been proved that the matter in suspension is retained in the upper bed of soil so cultivated; there is every reason to believe that the organic azotic matter is absorbed by vegetation or oxidized by the subsoil, which indefinitely retains its permeability.

3°. The Commission estimate that the entire of the sewage water of Paris, which (after the aqueduct from the Vanne is completed) will reach about 100 million cubic mètres per annum, can be disposed of on the surface of about 2000 hectares suited to this purpose in the peninsula of Gennevilliers.

Nevertheless, it would be convenient to apply part of the sewage to other lands, and for this eventuality that part of the Government lands of St. Germain which is near the Seine appears to offer a convenient site. The consideration of this question should be recommended to the immediate attention of the engineers of the City of Paris.

It is important in every respect to put promptly in execution the project submitted to the Municipal Council of Paris for the employment of a volume of water of at least fifty million cubic mètres per annum on a surface of 1000 hectares in the commune of Gennevilliers.

4°. By the early disposal of at least half of the sewage water in the plain of Gennevilliers by means of the works to be undertaken the state of the Seine will experience a sensible improvement, but which, however, will be far from sufficient. For the complete purification of the river it is necessary that the sewage water should be altogether diverted from it, and it is important that the City of Paris should hasten as much as possible the execution of additional works.

5°. As to purification by chemical processes, and in particular by sulphate of alumina, the Commission are of opinion that it will not constitute a complete and practical solution of the question; the application of these processes to the entire sewage waters would involve an expenditure, and difficulties in working, which are altogether disproportionate to the results obtained either from a sanitary or agricultural point of view. Chemical purification could only be employed temporarily and on a limited scale as an additional expedient in some particular cases.

6°. Dredging of the deposits formed in the bottom of the river should be continued with all the activity which is reconcilable with the public health.

7°. The water coming from the depôt at Bondy being the principal cause of the pollution of the departmental sewer which enters the Seine at St. Denis, it is urgent that this establishment should be altered so as to put an end to the great inconveniences which it causes; but the water now flowing from it can be carried without great expense, by the action of gravity alone, to the plain of Gennevilliers. These works are amongst those which should be at once executed.

8°. Although the waters from both the washing barges and secondary sewers still discharge into the Seine and contribute, at least at present, only in a secondary degree to the pollution of its waters, they are often very filthy, and their flow into the river is not without real inconvenience. The Commission call the attention of the Administration to put into most effective operation rules requiring the previous purification of these waters, now possible by comparatively inexpensive means, and specially by the system of employing them for agricultural purposes. It is of equal importance to adopt better regulations for preventing dead bodies of animals, or any filth whatever, being thrown into the river-course.

ADDITIONAL NOTE.

By M. Mille, Inspector-General des Ponts et Chaussées.

The Report of the Commission on the purification of the Seine has been submitted to the Council General *des Ponts et Chaussées* at their meeting on the 28th June, 1875. The conclusions of the Commission have been adopted in their essential particulars by the Council, and approved by a Ministerial decree of the 24th July following. The principles are therefore now decided on; as to the execution of the works, they were rapidly proceeded with during the season of 1875, during which about 125 hectares were irrigated in the first section (see Plate) by means of a portion of the sewage water of the Clichy sewer pumped by an engine of 150 H.P.; and the waters of St. Ouen were delivered by gravitation. A second engine of 250 H.P. was constructed so as to ensure a force of 400 H.P. The plain was intersected to the extent of 1000 hectares by a network of pipes 12 kilomètres long and of large diameters, varying from 0·60 to 1·25 mètre: the pipes, 0·60, 0·80, and 1 mètre in diameter, were in béton composed of Burgundy cement; the pipe of 1·25 diameter is in Portland cement masonry; the conduits, which have a pressure of 5 mètres of water, or half an atmosphere, have stood the pressure well.

By the aid of the engines and with an extension of the sewerage it is expected next year to remove from the Seine half of the sewage water which now pollutes it.

Finally, a preliminary project for an irrigation canal extending to the Forest of St. Germain has been prepared, in accordance with the opinion of the Commission; it has been submitted to the municipal administration, who have proposed to the Council to hold an inquiry and to obtain the "declaration of public utility" for the whole line from Clichy to St. Germain.

The City of Paris pursues the path which she was the first to initiate, and on which the other capitals, Berlin, Brussels, and Florence, now, by her example, follow.

"ASSAINISSEMENT DE BERLIN."

REGULATIONS AND WORKS.

NOTICE

By M. MILLE, Inspector-General des Ponts et Chaussées.

1. *Prefatory Remarks.*—Sanitary questions occupy public attention in Germany. To speak only of two capitals—Vienna, in completing the costly work of the rectification of the Danube, has at the same time obtained a supply of pure and cold water from Semmring; Berlin, which is still in a deplorable sanitary state, wishes to raise herself to the level of London and Paris, by providing at one and the same time water supply, drainage, and irrigation.

2. *The Water Supply of Vienna.*—Let us say one word on this subject.

Vienna, up to the present, has been supplied either from the impure and tepid waters of the Danube or the insipid and unwholesome water of wells. In the year 1860 measures were taken to obtain a supply of potable water, and it was decided to seek for it in the springs of Semmring, distant 95 kilomètres from the city, and at an elevation of 360 mètres above the summer level of the river. They issue from the snows of Schneeberg, in the calcareous zone of the Alps. Rain and melted snow filter through the fissures of the schist and appear in the form of springs, of which the principal are the Kaiserbrunn, in the *Valée d'Enfer*, and the *Sixten-quelle*, which issues from the pine woods of Richenau. The first has been given by the Emperor Francis Joseph to the City of Vienna; the second is the gift of Count Hoyos-Sprinzenstein. When mixed they have a mean temperature of 7 degrees. They discharge 70,000 cubic mètres per day, which gives a supply of 75 litres per head on a population of 940,000. It is scarcely possible to conceive the joy with which this supply of pure limpid iced water is now received in every house and on every floor in a hot and dusty climate.

Sanitary State of Berlin.—Let us pass to the improvements at Berlin. If water is the first want of Vienna, drainage at Berlin, as at London, is still a greater necessity in consequence of rain and the humidity of climate. This will explain the actual state of the city, and the improvement which the works now in course of construction will produce.

Berlin is altogether a modern city, for although it was a place of considerable trade in the middle ages, it owes its greatness to the dynasty of Frederick. Under Frederick I., after the revocation of the Edict of Nantes, and on the arrival of a colony of French refugees (1686), it had a population of only 20,000 inhabitants. A century afterwards, at the death of Frederick the Great (1786), the population was 114,000. It continued to increase each year. In 1872 it was 828,000, and at present it is probably 1,000,000.

Built upon a sandy plain on the banks of the Spree, a weak and sluggish river which flows through the marshes of the Havel into the Elbe, Berlin has a total area of 6250 hectares; 2560 only are built upon. The old town, situated on the right bank, marked by the Hôtel de Ville, lately constructed with feudal splendour, contains factories and stores. The new town, altogether on the left bank, has for its axis the boulevard *Unter den Linden* (under the lime trees), an avenue 50 mètres wide and 2 kilomètres long, planted with limes and chestnut trees. At the east end is the imperial palace, which is nothing more than the ancient castle. At the west end it is terminated by the Brandenburg gate (a triumphal arch with a Greek portico), which opens on the Thiergarten. Monuments, hotels, shops for the sale of articles of luxury, press on each other along this boulevard. Opposite the palace is the Museum, which, like the Louvre at Paris, is the pride of Berlin. A little farther on the Opera, then the University, which occupies the old palace of Prince Henry. The boulevard is intersected at right angles by wide streets, running from south to north from the station of the Dresden and Vienna Railway to that of the Hamburgh and Cologne. This quarter is named *Friederickstadt*, the city of Frederick I., who built it. Its thoroughfares are *Friederickstrass*, the street of shops and business; and *Wilhelmstrass*, which contains the government offices and the houses of the nobility. Beyond the Brandenburg gate, on the left, is what may be called the "West End"—the Park quarter—composed of terraces almost English, pavilions with verandas of stone and glass, decorated with foliage, and with mown grass and ornamental plants in front. Here wealthy families reside. Berlin, a frigid imitation of the antique in the monuments of the boulevard, has here a trace of the taste, habits, and climate of London.

In the midst of this rapid progress Berlin has, from a sanitary point of view, remained in a primitive state. The streets, badly paved, have pumps at regular distances, because the supply of water is principally obtained from the underlying bed of sand, although an English company distributes the waters of the Spree, taken and filtered on the upstream side of the city. The roads are bounded, narrowed, rendered dangerous by trenches which are 0·80 mètre deep, because they fulfil the functions of drains and collectors, and discharge into the nearest arm of the Spree the drainage of the streets and the houses. You cross these ditches by stone flags or planks, then an ill-paved interval, and enter the houses, which are divided in suites of apartments, as at Vienna and elsewhere. The rain from the roofs and the household water from the kitchens flow on the surface, the latrines discharge into covered wells or cesspools, and the Spree, with a small flow of water and slow motion, already polluted by the passage of boats carrying wood, bricks, merchandise, and vegetables, receives at all points the kennels of the different quarters of the city.

It was agreed on all hands that such a state as this could not be allowed to continue, and measures of amelioration have been discussed for the last twenty years. What was to be done? How were measures of improvement to be undertaken and executed? The great towns of Germany, Hamburg, Danzic, &c., had already employed English engineers to design their sanitary works. In the present case the improvement of the capital was confided to an engineer, M. Hobrecht, who had had considerable knowledge of England, and who had the support of the enlightened co-operation of his brother, the chief burgomaster—the Mayor of Berlin.

Sanitary Principles.—The principles of sanitary improvements were enunciated in the year 1851, in the celebrated Report of the Board of Health, written under the inspiration of Mr. Chadwick. They consist in constant circulation and in the restitution of the sewage to the soil, and an unlimited supply of pure water under pressure; or, as M. Belgrand has well said, a squandering of it (*gaspillage*) to the bathroom, the water-closet, and the kitchen, carrying with it all residue, *débris*, and filth. The water-closet especially is the *point d'appui* of domestic health, a substitute for cesspools, no longer festering with urine and other matter, which, carried away by a stream of pure water, will issue from it without offensive smell.

A house should be drained as a field is; no stagnant water should be allowed. The street should be also drained, the branch drains should be connected with the main sewers, which should not be permitted to fall into the river and pollute it; for along its banks other inhabitants dwell, whose rights to pure air and water should be respected. It is the soil which should receive the liquid sewage, which is as much a source of manure as the dungheap itself, and, like the dungheap, can by deep cultivation, and through the medium of crops, enter again without danger into the circle of life. Thus the four elements of the ancients, air, water, earth, and fire, acting by circulation on organic matter, are the sure principles of sanitary operations.

Rules for the Sanitary Improvement of Dwellings.—The following rules have been made:—By a police ordinance of the 14th of July, 1874, where a main sewer exists in a street and a district (*quartier*), every proprietor is bound to connect his property with the public sewer by a drain 0·16 mètre in diameter. This drain serves for the discharge of rain and household water, as well as the water-closets; but it is forbidden (in consequence of the small diameter of the drain) to throw into it solid *débris*, the refuse of the kitchen, cinders, or dirt. The cesspit is superseded by the water-closet; rain and refuse water no longer flows on the surface of the streets; there are no longer deep ditches crossed by flags; the space in front of the houses has become a footway (*trottoir*) with a granite curb, bounding a street with slightly curved surface and rectangular water tables, in cut stone.

In six weeks after a regular notification the proprietor submits a plan of the drainage of his property, according to the requirements of a police order dated the 8th of August, 1875. As a measure of precaution, the down pipes for the rain-water are terminated by a syphon apparatus, which retains any solid matter coming from the roof. The kitchen sink is furnished with a grate, the house drain is protected against the return of foul air from the sewer by a syphon and clack-valve, or flap, above which is a manhole to allow of inspection.

The order of the mayor, of the 4th September, 1874, completes these arrangements. It imposes a water rate (for the city has purchased the works previously executed by an English company for the supply of water from the sands of the Spree). After six weeks' notice, as in the case of drainage, the water rate is officially fixed.

The same decree settles the distribution of the works and the mode of levying their cost; those within the house are executed by the proprietor, those in the street by the public authorities. The decree goes further, for it gives the right to the authorities to construct the syphon, the valve, and the manhole, so as to ensure the proper junction of the drain with the main sewer; besides power is given to enter the house so as to make certain that the required conditions have been complied with, a breach of which is punished by fine, and even by imprisonment.

The expenditure to be recovered by the city is of two kinds; that relating to the house is charged for according to a fixed scale of prices, that for the construction and maintenance of the main sewers forms a separate charge. The principle adopted is that each house when connected with the public sewers pays a certain proportion of the expenditure, including maintenance and interest on capital. Ventilation is effected in connection with the houses; tables of the distribution of the rates are posted on the 1st of January next after inspection of the premises; repayments are made quarterly, as in other public levies, and in case of dispute an appeal lies to the Royal Council of Potsdam.

Thus water supply and drainage are obligatory; no proprietor can evade payment as soon as the main sewer has been established in the particular quarter in which his house is situated. The tax is not a fixed one, but proportional to the sanitary advantages obtained. This is almost similar to the French drainage law (*loi de desséchement*).

6. *Sewerage of the Public Streets.*—As water and liquid residuum from the houses are immediately discharged by the sewers, so it is in like manner from the streets. The method adopted is to make sewers in the line of the open drains along the public ways. Double and parallel lines of sewers corresponding with the footways are connected with others at the junction of streets which discharge into the main sewers. There are thus three systems; the third (*le riseau tertiare*), are formed with pipe tiles 0·22 mètre in diameter, which run in double lines through all the streets. The second, or branch drains, of stoneware pipes 0·45 mètre in diameter, or egg-shaped brick sewers regulated at the two-thirds; that is, in a drain measuring 1·20 mètre from invert to key, the width at two-thirds of the height is 0·80 mètre. Finally, sewers of the first order, or main intercepting or collecting

sewers: they are egg-shaped in brick, measuring 1·33 to 2 mètres, and can be easily examined.

The water from the streets reaches the sewers through grated gullies or sumps, in which the solid matter remains, the water flowing by syphon-trap into the sewer. At the junction of the streets and in the lines of the main and secondary sewers, there are manholes with plates at the surface through which a natural ventilation is effected.

Can the main sewers be connected with one outlet which will discharge into the river or deliver the sewage at a pumping station? No. Berlin is situated on a plain nearly level; the underground water lies near the surface, as if a large city were built on the plain of Gennevilliers; no excavation can be made without immediately meeting water. In consequence of this it is necessary to divide the sewerage into districts, each having works and pumping power.

Pumping Engines.—The surface built upon, as already stated, is 2560 hectares, divided into 1600 hectares on the right bank, forming two districts; and 960 hectares on the left bank, forming three districts; the population is very nearly equal, being about 400,000 inhabitants on each side of the river; but the most densely populated area is Friederickstadt (240 hectares), containing the boulevards, warehouses, hotels, and government offices. Here the works are finished and are in operation; the main sewers leading from the Brandenburg and Leipsic gates carry the sewage to an engine of 360 H.P., constructed close to the terminus of the Dresden railway. In advance of the suction-pipe the sewage is received into a large circular well 12 mètres in diameter, divided by a strainer—a precaution always taken to prevent the introduction of solids into conduits from which it is desired to exclude them. The engines are horizontal, connected with high-pressure double-acting pumps, with multiple clack-valves, for it is necessary to pump to a distance of 13 kilomètres, and at a height of 21 mètres above the pump; that is to say, that taking into account the volume to be discharged, it is necessary to work at a pressure of four atmospheres. Two metal pipes of 1 mètre and 0·75 mètre in diameter convey the sewage from the three pumping stations to Marienfelder; they discharge at a high level on an estate of 824 hectares, which is to be cultivated with vegetables, root crops, and green crops for fodder, already tried with success at Thiergarten. Similar measures have been taken on the left bank of the river, the two districts into which this part of the city has been divided, each has its own works and a separate conduit of 1 mètre in diameter, which enters at the extremity of a property at Falkenberg of 736 hectares in extent, 13 kilomètres distant from the city, and at an elevation of 30 mètres above the pumps; the working pressure is five atmospheres. Five engines, of about 400 H.P., are assigned to the different parts of a drainage which is estimated at 100,000 mètres per day including rain. Reference to the Plan will show that, in addition, two auxiliary stations are required, one on each side of the Spree and in the heart of the capital, to collect the sewage and to deliver it to the real distributing works placed at the circumference.

Such are the works, which will cost forty millions of francs, and an important function of which, the drainage of Friederickstadt, the luxurious quarter of the city, is in action since the 1st of November last. The sewage which the successive improvements in the houses sends to the main sewers is pumped and conveyed to the estate of Marienfelder, where the sands and cultivated plants revivify the waters and restore them in a pure state to the source from which they were taken. At once the circle is completed natural laws are satisfied; it cannot be otherwise as soon as the river ceases to be a sewer.

COMPARISON WITH LONDON AND PARIS.

To understand the whole scheme, the details of which may be criticised, but the boldness of which must be acknowledged, it is well to call to mind how sanitary matters proceed in London and Paris, the two cities which have served as models. In the north, where cold and wet demand a comfortable interior, and good internal arrangements, the house is the principal object of consideration; in our temperate climate, on the contrary, where we live much out of doors, the public streets require our chief care. The streets in England are not fine, but if you enter a house you find perfect domestic organization; kitchen, bathroom, water-closet, all have water in abundance, with an immediate discharge into the sewer, and as the servants' apartments are in the basement, a deep drainage is indispensable. A colossal system of sewage is required, since through it is drained a superficies of 21,000 hectares, inhabited by a population of four millions. The types of the sewerage are—the pipe-tile for the houses, the egg-shaped sewer for the streets, circular culverts in masonry (up to 3 mètres in diameter) for the intercepting sewers; when there is no fall, the pumping machinery acts incessantly, and discharges the sewage from both banks of the Thames. It is well known that it is proper to utilize this sewage (*ce courant des déjections*), which has cost so dear, since it represents the alimentation of the largest and richest city in the world. But they shrink from undertaking a fresh expenditure of one hundred million of francs for the cost of irrigation works; they wait to have it undertaken by private enterprise, and they leave little towns, such as Merthyr, to create examples, of which they boast, but which the metropolis has not yet followed.

Let us turn to the case of Paris. The rooms are arranged in a charming manner. One must go to the east of Europe, and see the dreariness of a room with an earthenware stove, to realize how an open fireplace with a blazing fire of wood adds to the beauty and cheerfulness of the apartment. As to domestic arrangements, they are improving, but still imperfect. The kitchen is small, and without a scullery. It is rare to find a bathroom, especially with proper mechanical arrangements for the supply and discharge of water. The water-closet is a luxury, and the odours from the cesspit occasionally invade the drawing room. Outside, on the contrary, everything is almost perfect. Façades of hard white stone, suitable for sculpture, the perspective of monuments, fountains, wide footways in granite or asphalte, streets swept and watered ; in a word, everything that can make an outdoor life pleasant and agreeable. But, moreover, the *ménage* of the public ways is performed underground ; everything is thrown into the mouths of the sewers—sand, mud, and even "macadam" ; from thence there is an extended system of main sewers, everywhere accessible to the workmen who clean them. The intercepting sewers, or "collectors" (having a banquette), admit rails and waggons. Water-pipes can be placed in them, and perhaps gaspipes, as Mr. Haywood has done at the Holborn Viaduct. The outlet is large enough to admit a boat ; it is the *Cloaca Maxima* of Rome improved by modern science. Beyond the outlet commences the process of restitution of the sewage to the soil. The city accepts the obligation of preventing it from flowing into the river, and has at great cost provided the means of irrigation, without charge, to the plain of Gennevilliers. Everyone takes water as he pleases and uses it as it suits the cultivation of the land, and notwithstanding interested complaints the movement extends each year without losing any ground once gained. It has been said that the land would be covered with a crust impenetrable to water ; the plough turns up a black earth, rich and light. It has been asserted that cellars would be flooded and the water of wells defiled ; the extent of the sheet of underground water is so vast that the addition of the irrigation water causes no sensible difference in its level. Finally, it has been affirmed that fever and malaria arise from those rivulets of black water ; but, contrary to what has too often occurred in Algeria, none of the workmen have been ill. Double crops have been so profitable to the cultivator that he each year extends his garden or his field, and the land pays three times what it was formerly let at. Paris has then recognized and applied three principles—water abundant and pure, the Vanne being the equivalent expression to the sources of the Semmring at Vienna; a system of underground sewers, most ample in section, most accessible to the circulation of water and air, as well as to inspection; finally, the irrigation of a sandy soil, permeable and cultivated, which assures the revivification of impure water. But there is nothing obligatory except the drainage beneath the public streets; the supply of water to the houses and the irrigation of the plain are left free to private enterprise.

Resumé and Conclusions.—Berlin, which had everything to accomplish, and was placed between these two models of London and Paris, has resolutely taken her part. It was first necessary to improve the house; the regulations require that it should be supplied with water, a water-closet, and a means of discharge into the main sewer. To obviate the apathy of the owners, after a notice of six weeks a plan of the drainage must be furnished to the authorities, who proceed to execute the works if the owner neglects to do so. The streets had no footways or regular roadways; an underground drainage replaces the dangerous ditches used as sewers. The third-class sewers are connected with small oval branch drains discharging into the sewers of the first class, which are also oval. Liquids alone are permitted to enter, and precautions are taken by means of syphons and sumps to prevent the entry of solids, which are removed by hand labour, and which will be certainly costly and perhaps insufficient. Free entry by gullies, as at Paris, with sewers of large section and banquettes, are without any doubt preferable, as less attention may be paid to solids, which will be removed by the current and the self-moving action of the cleaning boats. But as at Berlin the land is level, and water is near the surface, it was necessary to adopt a shallow system of drainage, hence the necessity of having five pumping stations, one for each district. Even this is not sufficient, for it was necessary to have two auxiliary stations on the banks of the Spree, to carry the drainage from the centre to the circumference, to be thence sent to the country.

The restitution of the sewage waters to the land is frankly accepted. Two estates of 800 hectares have been acquired, at a distance of 13 kilomètres from the city, and at a height of from 20 to 30 mètres above the pumping level. The delay which would be caused by waiting till the farmers were convinced of the advantages of irrigation, and voluntarily applied the sewage to their lands, could not be thought of. From the day the engines commenced pumping from the new town, Friederickstadt, they have irrigated the sands of Marienfelder; the result is a bold one. This no doubt is only a beginning, and it will take at least ten years to expend the whole forty millions of francs, the first ten of which are now represented by M. Hobrecht's works. But the chief difficulty is accomplished. A precise knowledge of the true solution of the question has been gained, and is indeed realized; the rest, including improvements, will come in due time.

If, in conclusion, we are permitted to offer an opinion, we repeat our conviction that the interchange and adoption of practical details is progress. We should go to the north to study the internal improvement of the private house, and to Paris to see that of the public way. In adopting that which is good in each, as far as the circumstances of each case will permit, we shall develope the science of health, and health itself, and prolong the mean duration of life of the inhabitants of large towns.

PARIS, *5th of November*, 1875.

N.B.—I am indebted for the particulars of this paper and the plan to the science and kindness of M. Hobrecht, engineer-in-chief for the sanitary works of Berlin.

DOCUMENTS ANNEXED.

1. POLICE ORDINANCE, July 14, 1874.
2. ORDER OF THE MAYOR, September 4, 1874.
3. POLICE ORDER, August 8, 1875.

POLICE ORDINANCE.

By virtue of Articles 5, 6, and 11 of the Law of the 11th of March, 1850, the Prefect of Police, with the approval of the Common Council of the City of Berlin,

ORDERS.

§ 1. In the streets and quarters of the city already provided with subterranean sewers, each house shall be connected to the public sewer by a branch drain.

This drain will serve for the discharge of rain and household water as well as for water-closets; but solid matter, filth, the sweepings of the kitchen, cinders, or sand, will not be permitted to be thrown into it.

§ 2. In the quarters of the city where sewerage works have been executed, no new cesspit will be authorized. After six weeks' notice the existing open ditches will cease to be in communication with the house drains.

§ 3. In six weeks after due publication of the change of drainage the proprietors or their agents are bound to submit a plan for the complete sewerage of their houses to the authorities. The execution of the works must be commenced in six weeks at latest after the plan has been approved of.

§ 4. The drains must not be used till an inspection of them has been made, and it is found that they have been executed in accordance with the approved plan.

§ 5. Immediately on the completion of the main sewer all drainage on the surface will be prevented.

§ 6. The existing junctions of the houses with the kennels will be done away with, or be modified as follows:—

The air-pipes from the ditches will be continued to the roofs or put in communication with the chimneys.

The kitchen sinks will be provided with a fixed grate, and will be trapped, as will also the pipes from water-closets.

Rain-water will be discharged through grates, the construction of which will be submitted to control.

The house drains will be built along the front wall, will be trapped, and furnished with a self-acting clack-valve, or flap, at their junctions with the main sewers.

The down pipes will flow directly to the sewer, but through a sump, which will retain any solid matter from the roof.

§ 7. The discharge, on the surface, of factory or condensing water will be permitted by special leave.

§ 8. The footways will be divided from the roadway by a granite curb 0·25 mètre by 0·30 mètre.

§ 9. All former regulations contrary to the present ordinance are hereby revoked.

§ 10. Infractions of those rules not provided for by the existing laws will be punished by fines varying from 1 to 30 thalers, or, in case of non-payment, by imprisonment.

Such imprisonment will not prevent the execution of works by the authorities if necessary.

VON HERTZBERG,
Prefect of Police.

Berlin, 14*th July*, 1874.

ORDER OF THE MAYOR.

By virtue of the 11th Article of the Ordinance of the 30th of May, 1853, and the 1st Article of the Ordinance of the 14th July, 1874, the Mayor of Berlin orders as follows:—

§ 1. In the execution of the branch drain connecting the house with the public sewer, the portion under the public way and footpath up to and including the flap, or clack-valve, appertains to the authorities.

The remainder of the sanitary works of the house appertains to the proprietor.

§ 2. The suppression of the open ditches, the fixing of the curbing and its connection with the roadway appertain to the authorities; the cost to be paid by the inhabitants along the ditches in proportion to their frontage.

§ 3. No modification of the drainage of a house can be made without authority.

§ 4. Inspectors have a right of entry to examine the state of the works.

§ 5. All dwellings placed in connection with the main sewers must also be connected with the water supply.

§ 6. The proprietor is bound to apply to the director of the water supply to be rated on the usual conditions.

If after six weeks' notice this has not been done, the work will be executed at the cost of the proprietor.

§ 7. Each house connected with the main sewers must pay a proportional contribution quarterly. The amount is determined by the authorities, and published at the commencement of the current collection of rates. The total contribution includes the cost of maintenance and interest on capital.

§ 8. The works executed at the cost of the proprietors are regulated according to a tariff approved of by the administration.

§ 9. Money payable by the proprietors is to be recovered in the same manner as other public rates.

§ 10. A delay of six weeks is accorded to persons wishing to appeal to the Royal Council of Potsdam against the decisions of the municipal administration in the matter of water supply and drainage.

Pending this appeal the rate must be paid.

§ 11. The present order will be revised in two years.

Approved 11th Sept., 1874.

VON BRAUCHITSCH,
Minister of the Interior.

Berlin, 4th Sept., 1875.

HOBRECHT,
Mayor.

POLICE ORDER.

By virtue of Article 10 of the Ordinance of 14th of July, 1874, which requires the lodgment of a plan for the sanitary works of each house, the Prefect of Police directs,

The plan shall comprise the following particulars:—

1. A general plan of the tenement.
2. Plan of basement.
3. Section of the building from the basement to the roof.
4. Outline of the project, with dimensions and levels of branch drains, and a specification of the nature of the materials.

The project to be accompanied by a certificate from the proprietor or his agent, giving the name of the street, number of the house, a description of the several parts of it, and heights measured from the level of the footway.

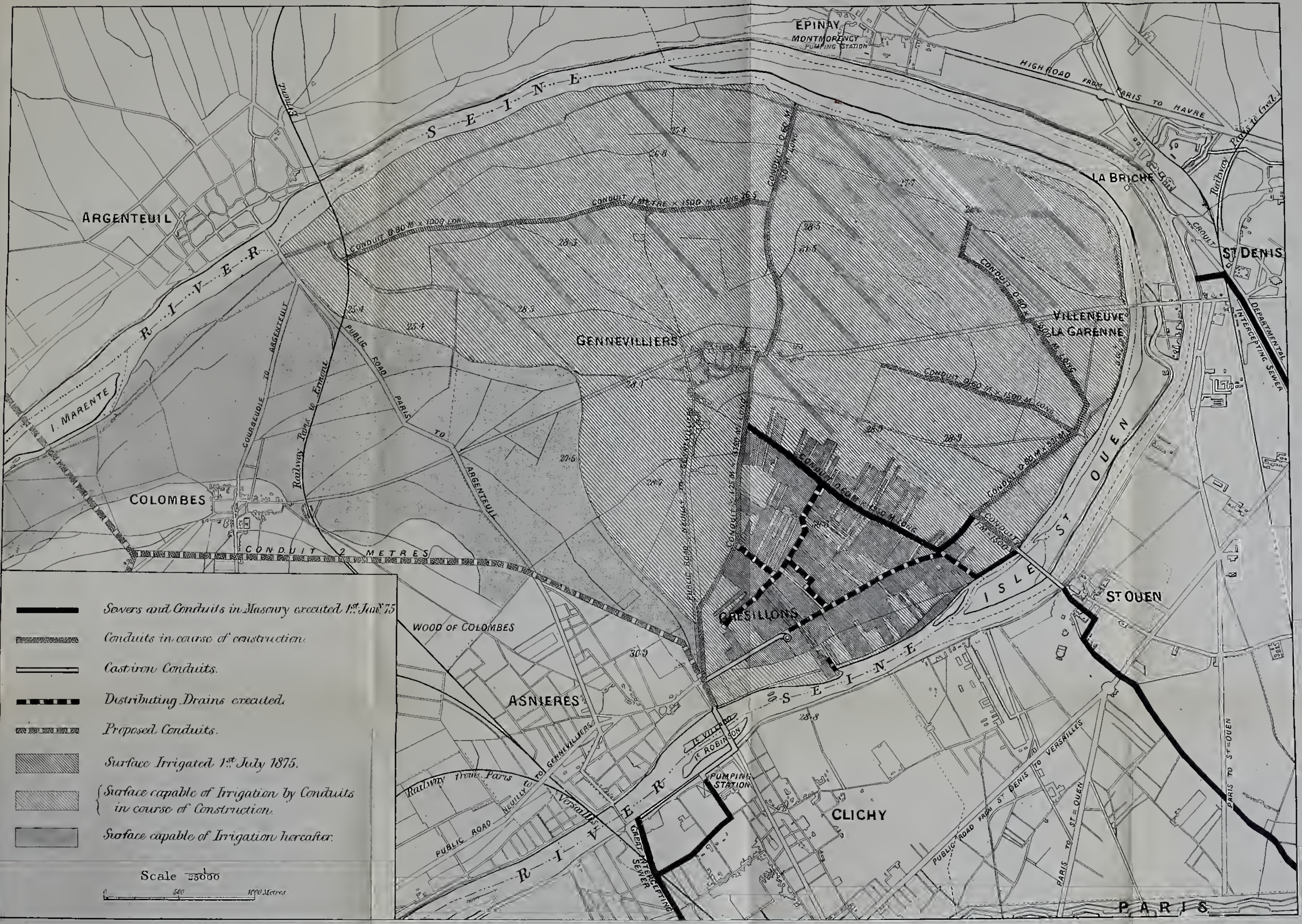
It is recommended that the preparation of the plans be confided only to experienced men, so as to avoid their rejection.

VON HERTZBERG,
Prefect of Police.

Berlin, 8*th August*, 1875.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET AND CHARING CROSS.

"ASSAINISSEMENT DE LA SEINE" UTILIZATION OF THE SEWAGE WATER.


EPINAY
MONTMORENCY
PUMPING STATION
HIGH ROAD FROM PARIS TO HAVRE
Railway Paris to Creil
LA BRICHE
ST DENIS
DEPARTMENTAL INTERCEPTING SEWER
S E I N E
ARGENTEUIL
R I V E R
I. MARENTE
Ermont
CONDUIT 0.80 M × 1000 LONG
CONDUIT 1 METRE × 1500 M. LONG
GENNEVILLIERS
VILLENEUVE LA GARENNE
PUBLIC ROAD PARIS TO ARGENTEUIL
COURBEVOIE TO ARGENTEUIL
Railway Paris to Ermont
COLOMBES
CONDUIT 2 METRES
WOOD OF COLOMBES
GRESILLONS
ISLE ST OUEN
ST OUEN
ASNIERES
S E I N E
Railway from Paris to Versailles
PUBLIC ROAD NEUILLY TO GENNEVILLIERS
R I V E R
GREAT INTERCEPTING SEWER
PUMPING STATION
I. VILLIERS
I. ROBINSON
CLICHY
PUBLIC ROAD FROM ST DENIS TO VERSAILLES
PARIS TO ST OUEN
PARIS
Sewers and Conduits in Masonry executed 1st Jany 75
Conduits in course of construction.
Castiron Conduits.
Distributing Drains executed.
Proposed Conduits.
Surface Irrigated 1st July 1875.
Surface capable of Irrigation by Conduits in course of Construction.
Surface capable of Irrigation hereafter.
Scale 1/25000
0
500
1000 Metres

ASSAINISSEMENT DE BERLIN.